REPORT

ON THE

Clear Lake Power and Irrigation Project

BY

W. A. CATTELL
Consulting Engineer

SAN FRANCISCO, CALIFORNIA
April 15, 1909

REPORT

ON THE

Clear Lake Power and Irrigation Project

BY

W. A. CATTELL

Consulting Engineer

SAN FRANCISCO, CALIFORNIA

April 15, 1909

Printed by
The Stanley-Taylor Company
San Francisco

TABLE OF CONTENTS

TABLE OF CONTENTS,—Continued

Mr. E. P. Vandercook, Manager,
Clear Lake Power & Irrigation Co.,
Union Trust Building,
San Francisco, Cal.

Dear Sir:

After a most careful investigation of the engineering and financial features of the Clear Lake Power & Irrigation project which you have inaugurated, I beg to transmit to you the accompanying report, which discusses the more important of these features somewhat in detail.

For your convenience I will here state briefly the conclusions at which I have arrived in making this investigation and which are set forth more fully in the report.

These conclusions are:

(1) That the minimum flow of water which you will have available at the Rumsey Power House in the dryest season of which we have any record will be 500 cubic feet per second.

(2) That this flow, together with the additional supply which can be obtained from the North Fork of Cache Creek will generate 42,817 continuous Horse Power in the two power houses, and that a rational use of this power will enable you to deliver in San Francisco and Oakland a total of 200,000,000 K. W. hours per annum.

(3) That there is an ample market for all of this power in San Francisco and the Bay District, and that the minimum price you should expect to receive for this power is 8-10 of a cent per Kilowatt hour, which would produce a gross revenue of $1,600,000.

(4) That after generating the power as above stated the water can be used to irrigate 200,000 acres of land and will produce an average annual revenue of $2.00 per acre, or $400,000.

(5) That the entire cost of developing the property to an earning capacity of $2,000,000 per annum will not exceed $7,500,000, including the purchase of all necessary lands, water rights, and the construction of dams, conduits, power houses and transmission lines.

(6) That the ultimate returns to the Company from the sale of water rights for irrigation and enhanced value of the lands which have been acquired around Clear Lake should be not less than $7,000,000.

This project should commend itself, not only as a profitable business investment, but also as a means of exemplifying in an unusual degree the benefits arising from the conservation and development of our natural resources.

An enterprise which will yield a sure and ample return upon the capital invested, and at the same time add materially to the wealth of the State, by supplying power for the operation of its industries, and water for the irrigation of large areas of valuable and fertile land, is surely one which will reflect credit upon its projectors, and which should enlist the support of all who are interested in the development of California.

Copies of this report have been submitted to Mr. A. M. Hunt, and to Mr. Rudolph W. Van Norden, both consulting engineers of San Francisco, whose work in connection with the construction and operation of Hydro-electric plants in California is widely and favorably known. The comments of these engineers, upon the conclusions which have been reached will be found in the appendix.

In the Appendix will also be found a copy of a letter from Attorney Charles S. Wheeler, relating to the legal status of the lands and water rights of the Company.

Very respectfully yours,

W. A. Cattell.

REPORT
on the
CLEAR LAKE POWER & IRRIGATION PROJECT
by

W. A. Cattell, C. E.
San Francisco, Cal., April 15, 1909.

SCOPE OF PROJECT.

The project herein described contemplates utilizing the storage possibilities of Clear Lake, by the construction of a dam at its outlet, conducting the water from this dam some four miles in the natural channel of Cache Creek to a diverting dam, thence by a series of ditches, flumes and tunnels, aggregating 22 miles in length, to Rumsey, where the Main Power House will be located and where a fall with an effective head of 750 feet can be obtained.

After passing the Rumsey Power House the water will be conducted by an inexpensive ditch, some 20 miles in length, already partially constructed, to Capay where an additional fall with an effective head of 160 feet can be obtained.

After passing the Capay Power House, the water will be delivered to the system of irrigating canals and ditches now in use by the Yolo County Consolidated Water Company. By improving and extending this ditch system the water can be used to irrigate a large area of fine fruit and alfalfa lands in Yolo and Solano Counties.

A high tension transmission line will be constructed to transmit the power generated by the falling water to Oakland, San Francisco and other points where it can be sold.

SOURCE OF SUPPLY AND AMOUNT OF WATER AVAILABLE.

The most vital consideration in the establishment of a hydro-electric plant, or an irrigation system, is to determine, as accurately as possible, the amount of water which will be available at all times and the power which this water will develop.

As the water for the development of power and the irrigation of lands under this project will be derived principally from the flow of Cache Creek, the only outlet of Clear Lake, it is necessary to know the amount of water entering the Lake each season, or the amount discharged by Cache Creek.

DESCRIPTION OF LAKE AND WATER SHED.

Clear Lake is situated in Lake County, California, in Lat. 39 degrees 00 minutes North, Long. 123 degrees 00 minutes West, 90 miles north of the City of San Francisco.

It will be noted on referring to the accompanying sketch map, that the Lake is exceedingly irregular in outline. Its total length is some 22 miles with a maximum width of eight miles.

The area of the Lake at various elevations above the datum assumed by Mr. Wm. Ham Hall in his Topographical Survey of 1889 (see Page 8), are given in the following table from p. 33 of W. S. & Irrigation Paper No. 45.

AREAS OF CLEAR LAKE, CAL., AT DIFFERENT ELEVATIONS.

ELEVATION OF PLANE.	AREA OF PLANE.	
Feet.	Square Miles.	Acres.
90	56,852	36,385
92	58,071	37,165
94	59,255	37,923
96	60,614	38,793
98	62,156	39,780
100	63,784	40,822
102	64,726	41,425
104	67,061	42,919
106	69,203	44,290
108	70,530	45,139
110	72,036	46,103

The mean elevation of the surface of the Lake is 1,329 feet above sea level.

The Lake has a maximum depth of about 50 feet. It is fed by numerous streams and springs some of which are perennial.

The drainage area which supplies Clear Lake comprises about 500 square miles including the area of the Lake itself.

On the easterly side of the Lake the hills come close to the water, rising within half to three-quarters of a mile, from 1,000 to 2,000 feet above it. The hills are also close and precipitous on the westerly side of the southern portion of the Lake, but west of the northerly portion, and north of the Lake, are many thousands of acres of the most fertile farming lands in the State. Beyond these the hills rise again from 2,000 to 3,000 feet above the water. On the northerly slopes of the watershed there are large bodies of fine timber lands—white oak, yellow pine and fir.

CACHE CREEK.

The outlet of the Lake is from its southerly extremity through Cache Creek. This Creek flows in a general easterly direction through a comparatively open country for the first four miles, then turns to the north and enters a steep and narrow canyon. The average fall in the first four miles is from four to five feet to the mile, but from the beginning of the canyon the rate of descent increases very rapidly for the next 25 miles,

until at Rumsey it reaches an elevation of 420 feet above tide water, a total drop from the Lake of 909 feet.

At Rumsey the Stream enters the head of the Capay Valley through which it flows past Capay, Esparto and Madison and passing north of the town of Woodland loses itself in the tule lands west of the Sacramento River.

AVAILABLE DATA.

The available data from which the amount of water entering the Lake, or discharged from Cache Creek may be computed, are three-fold:

(*a*) Rainfall.
(*b*) Discharge Measurements of Cache Creek.
(*c*) The fluctuations of the surface of the Lake.

(*a*) RAINFALL.

The topography of the Clear Lake drainage basin is such that it is practically impossible to establish any definite or satisfactory ratio of run off to rainfall.

Rainfall records have been kept at various points in the basin since 1874. Unfortunately all of those records were kept at points whose elevation was practically that of the Lake, and within a mile or two of its shores.

It is a well known fact that the precipitation on most of the California watersheds increases directly as the elevation. This rate of increase is well defined on the westerly slope of the Sierra Nevada Mountains, but it is not so clearly defined for the Clear Lake drainage.

While it is at once apparent from a comparison of the rainfall records at the Lake level, and either the discharge measurements as given by the U. S. Geological Survey, or the rise and fall of the Lake since 1873, that the average rainfall on the entire drainage area is very much greater than the rainfall as measured at the Lake level, it has been impossible to determine with any degree of certainty how much greater. This is probably due to the fact that when the storms come from the west or southwest the hills to the west and southwest of the Lake catch the greater part of the precipitation, a considerable percentage of which sooner or later runs into the Lake. In such cases the rainfall in the hills is probably from two to three times the amount recorded at Lakeport or Kono Tayee.

In the case of storms coming from the south or southwest a large part of the precipitation is caught by the hills to the south of the Lake and is discharged into Cache Creek, by Herndon and Siegler Creeks below the gaging station at Lower Lake, and consequently is not measured with the discharge at this point, and except for brief periods when the discharge from Siegler Creek causes Cache Creek to flow back into the Lake, has no effect upon raising the Lake level.

In such storms the precipitation on the hills to the east and west of the Lake, is probably little if any greater than the precipitation as measured at the Lake level.

There are no data available as to direction, duration or intensity of the storms which visit this region, and without such data or rainfall records over the entire basin, it seems impossible to establish any satisfactory ratio of run-off from the rainfall as recorded at the Lake level.

The records of seasonal rainfall, by months, as given on page 7, are carefully compiled and averaged from the records kept at Kono Tayee, Upper Lake, Lakeport, Lower Lake and Kelseyville. With the exception of the latter, all the stations are on the shores of the Lake. Kelseyville is situated about two and a half miles southeast of the Lake and at practically the same elevation.

RAINFALL AT CLEAR LAKE, CALIFORNIA IN INCHES.

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Totals.
1873-4	....	....	....	....	1.88	3.60	4.62	2.05	.45	....	....	....	12.60
1874-5	....	3.70	6.25	.29	9.16	.38	.92	....	.84	.42	....	....	21.96
1875-6	....	1.17	6.96	5.12	6.05	4.22	8.34	.10	....	....	....	....	31.96
1876-7	....	.20	3.50	....	3.17	2.81	7.40	.50	....	.50	....	....	12.08
1877-8	.73	1.65	2.23	1.98	14.16	11.04	4.60	1.43	.79	.45	....	.07	39.13
1878-9	....	.41	1.37	.33	3.01	3.41	9.15	.47	.64	....	....	.05	18.84
1879-0	....	.91	3.57	5.72	6.24	3.85	4.74	.48	.25	....	....	....	25.76
1880-1	....	....	3.54	1.92	5.50	6.58	.64	.95	.12	....	....	....	19.25
1881-2	....	.63	2.90	1.77	1.74	3.20	2.34	1.54	.40	....	....	....	14.52
1882-3	.42	1.64	4.42	.98	1.40	.60	3.81	.95	2.41	....	....	....	16.63
1883-4	.70	.99	.39	.70	4.17	1.91	5.35	3.88	.06	4.08	....	....	22.23
1884-5	.77	.66	....	8.26	1.47	.51	....	1.70	....	.43	....	....	13.80
1885-6	.63	.23	15.37	3.51	5.90	....	1.20	3.75	.85	....	....	....	31.44
1886-7	1.00	.40	2.00	1.10	7.50	1.40	1.50	.10	.10	....	....	....	15.10
1887-8	.20	.20	.60	3.40	6.70	1.60	2.80	.10	.50	.70	....	....	16.80
1888-9	.90	....	5.00	6.00	1.00	.40	8.00	.80	2.60	.10	.10	....	24.90
1889-0	....	7.50	3.60	11.50	11.50	4.00	9.20	1.60	.70	....	....	....	49.60
1890-1	.20	....	....	4.80	1.30	9.70	1.20	2.50	.60	.30	.10	....	20.70
1891-2	.80	.50	.50	7.00	4.00	2.50	2.60	2.60	3.30	.50	....	....	24.30
1892-3	.10	1.00	6.70	6.90	3.80	5.00	5.70	2.20	.80	....	....	....	32.20
1893-4	.60	.50	4.50	2.80	10.00	6.00	1.50	1.30	1.00	1.20	....	....	29.40
1894-5	.60	1.60	.90	12.00	14.60	3.10	3.60	1.10	1.20	....	....	....	38.70
1895-6	1.20	....	1.80	3.20	12.70	.70	2.30	5.50	1.70	.20	....	.80	30.10
1896-7	.40	1.00	4.30	6.60	3.20	6.00	4.10	.50	.30	.80	....	....	27.20
1897-8	....	1.50	1.90	2.10	.70	5.50	.10	.60	1.60	.50	....	....	14.50
1898-9	.70	.90	1.20	1.50	8.60	.10	6 40	.50	.50	.30	....	....	20.70
1899-0	....	4.20	6.70	5.30	3.50	1.30	3.50	2.30	.50	.10	....	....	27.40
1900-1	....	3.70	4.90	3.30	7.10	4.40	1.20	2.20	.80	.20	....	....	27.80
1901-2	.90	1.20	4.20	1.60	1.50	12.50	3.80	2.90	1.90	....	....	....	30.50
1902-3	....	4.30	6.70	3.10	5.00	2.00	4.00	.20	.10	....	....	....	25.40
1903-4	....	1.10	9.10	3.10	1.20	12.20	11.30	2.30	.10	....	.10	....	40.50
1904-5	3.00	4.00	1.80	6.60	8.70	4.10	5.60	1.00	2.70	.10	....	....	37.60
1905-6	....	....	1.70	1.70	12.70	6.00	6.30	1.00	2.60	.60	....	....	32.60
1906-7	.05	....	2.29	9.01	6.70	5.02	14.37	....	.32	.94	....	....	38.70
1907-8	.05	1.27	.14	9.14	4.47	6.95	1.83	.26	.74	....	....	....	24.85
Means	.40	1.34	3.46	4.07	5.72	4.07	4.23	1.41	.90	.35	.01	.03	25.99

(*b*) DISCHARGE MEASUREMENTS.

The fluctuations of the surface of Clear Lake have been recorded by gages stationed at Lakeport and Kono Tayee since 1873.

These gages had their zero placed at the low water mark of that year.

In 1889, Mr. Wm. Ham Hall made a topographical survey of the Lake for the U. S. Geological Survey. He assumed a datum on which elevation 100.00 = 1.27 on the old gages.

The mean monthly elevations of the surface of the Lake as observed on these gages, were collected by Mr. Chandler, reduced to the datum assumed by Mr. Hall and published in Water Supply and Irrigation Paper No. 45.

On January 1, 1901, the U. S. Geological Survey established a gaging station at the outlet of the Lake, at the wagon bridge, crossing Cache Creek, ¾ miles north of the town of Lower Lake, and daily readings of this gage have been maintained since that date.

On November 20, 1898, the Lake made a new low water record, viz., 97.75 or one foot lower than the low water of 1873, which was 98.75, and the gage placed on January 1, 1901, near Lower Lake had its zero at this low water mark, at 97.75, or one foot lower than the old gages at Lakeport and Kono Tayee.

On March 26, 1903, the U. S. Geological Survey established a new gage near the wagon bridge in place of the 1901 gage. The new gage has its zero 1.30 feet below the zero of 1901 gage, or at elevation 96.43 of Mr. Hall's datum.

For convenience of reference the mean monthly gage heights, as observed on the gages of 1901 and 1903, have been reduced to Mr. Hall's datum, and the accompanying diagram showing the fluctuations of the Lake since 1873 plotted accordingly.

The following table shows the discharge measurements in acre feet as computed by the U. S. Geological Survey from 1901 to 1908, inclusive, with the exception of the discharge for 1908, which was computed by the writer from gage heights for 1908, furnished by Mr. W. S. Clapp, District Engineer of the U. S. Geological Survey.

DISCHARGE MEASUREMENTS IN ACRE FEET OF CACHE CREEK, NEAR LOWER LAKE, AS COMPUTED BY THE U. S. GEOLOGICAL SURVEY, 1901 TO 1908, INCLUSIVE

	1901	1902	1903	1904	1905	1906	1907	1908
January	32,896	3,259	23,304	13,281	27,550	19,400	23,100	16,700
February	50,483	21,160	39,542	31,119	49,100	37,500	46,400	35,400
March	66,345	108,587	44,517	159,130	57,370	75,000	107,000	44,600
April	38,916	84,912	44,033	166,671	58,970	89,800	143,000	32,400
May	29,576	53,187	32,773	89,772	43,160	55,000	83,600	27,500
June	19,458	33,084	19,993	45,342	28,320	38,000	44,600	12,600
July	12,236	23,365	12,789	29,699	18,080	26,000	28,600	8,400
August	7,010	14,941	6,825	18,569	10,640	15,700	16,500	5,000
September	3,273	9,699	2,975	11,187	5,861	8,930	9,940	1,800
October	1,906	7,809	1,353	10,330	3,443	6,330	7,820	.....
November	1,547	15,650	3,213	8,509	1,791	4,720	6,250	.....
December	3,812	18,877	10,330	10,145	1,888	8,180	8,120	.....
Totals	263,858	394,530	241,647	593,754	506,200	385,000	525,000	184,400

Total for the eight years..................2,894,389 acre feet.
Average per annum.................... 361,798 acre feet,

or 15,760,000,000 cubic feet per annum, which equals a continuous flow of almost exactly 500 cubic feet per second.

This record includes two exceptionally dry years for all California water sheds, viz., 1905 and 1908.

(*c*) FLUCTUATIONS OF THE SURFACE OF THE LAKE.

From the foregoing discharge measurements, a curve was prepared (Plate A) showing the discharge in cubic feet per month for each mean monthly Lake level and from this curve the discharge for each month, from 1874 to 1900, inclusive, was computed.

In order to determine as nearly as possible the actual volume of water which entered the Lake in each season from low water to low water of the following calendar year, effective for use, i. e., in addition to evaporation and seepage, the total volume entering the Lake as indicated by its vertical rise from low water to high water was first computed for each year. To this was added the amount discharged during the rise as given by the mean monthly lake levels and the discharge curve (Plate A), as this amount of water must have entered the Lake in addition to the volume producing the vertical rise. To this sum was added as a plus or minus quantity, the difference in volumes indicated by the vertical fall, and the volume discharged during the fall, as obtained from the discharge curve and mean monthly lake levels. If the volume shown by the latter exceeded the volume shown by the vertical fall, it was added to the sum first obtained; if the reverse, it was deducted.

While this method is, of course, dependent in its last analysis on the discharge curve, it has the advantage of showing the actual volume which entered the Lake each season between low water and low water, over and above evaporation and seepage, and at the same time recognizes the actual difference in Lake levels from season to season.

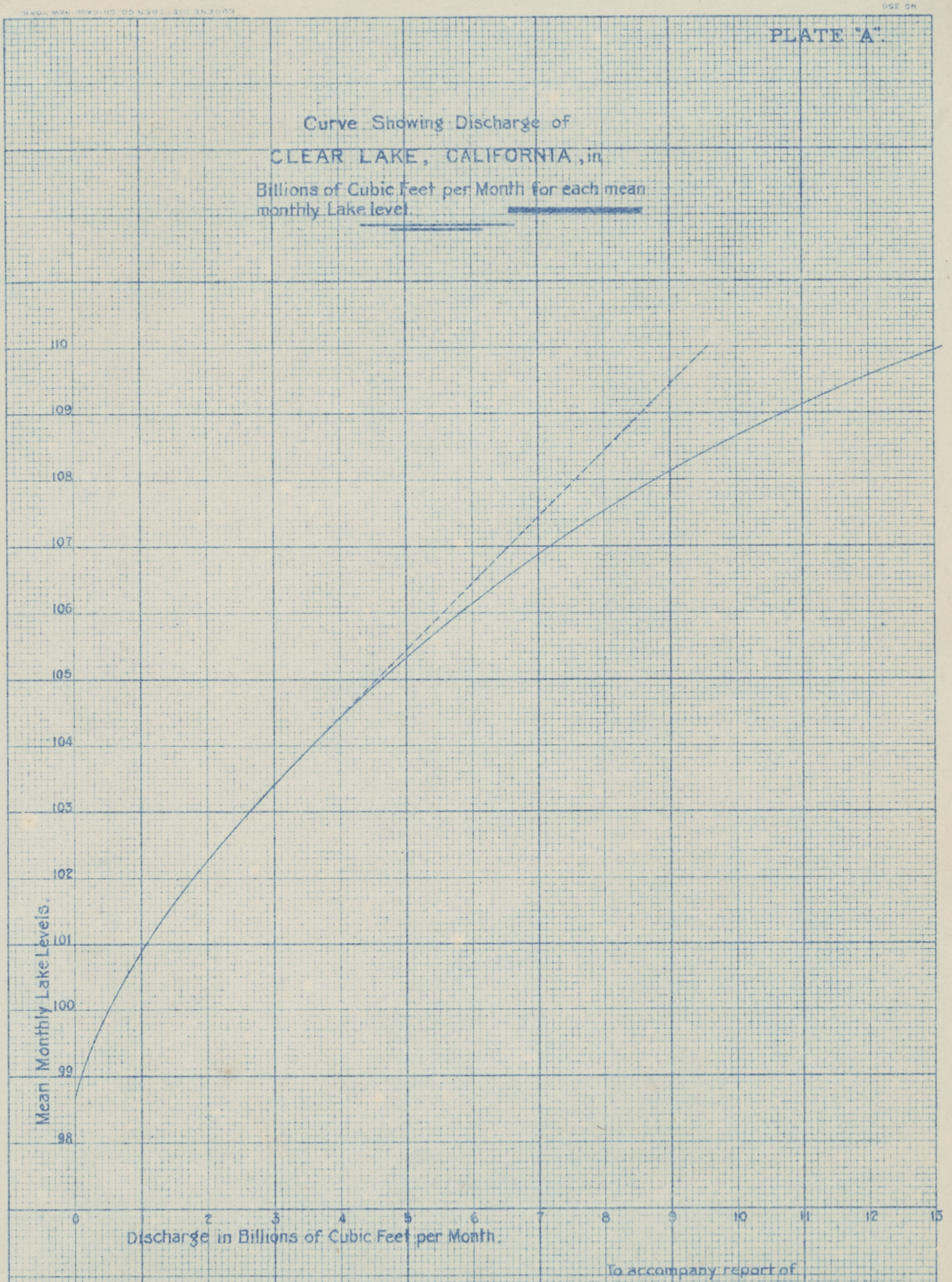


PLATE "A".
Curve Showing Discharge of
CLEAR LAKE, CALIFORNIA, in
Billions of Cubic Feet per Month for each mean monthly Lake level.
Mean Monthly Lake Levels.
110
109
108
107
106
105
104
103
102
101
100
99
98
0
2
3
4
5
6
7
8
9
10
11
12
13
Discharge in Billions of Cubic Feet per Month.
To accompany report of
W. A. Cattell,
Consulting Engineer.

In making these computations the average area of the Lake was assumed at 65 square miles. The results as thus obtained and expressed in both acre-feet and cubic feet, are tabulated below:

SEASONAL INTAKE OF CLEAR LAKE, CALIFORNIA

Over and Above Evaporation and Seepage

1873-4 to 1907-8, Inclusive.

Season.	*Acre Feet.*	*Cubic Feet.*
1873-4	916,666	39,930,000,000
4-5	428,374	18,660,000,000
5-6	1,369,375	59,650,000,000
6-7	262,397	11,430,000,000
7-8	1,241,276	54,070,000,000
8-9	702,709	30,610,000,000
9-0	992,883	43,250,000,000
1880-1	960,285	41,830,000,000
1-2	393,021	17,120,000,000
2-3	217,172	9,460,000,000
3-4	313,590	13,660,000,000
4-5	342,057	14,900,000,000
5-6	1,115,932	48,610,000,000
6-7	303,260	13,210,000,000
7-8	251,607	10,960,000,000
8-9	470,156	20,480,000,000
9-0	1,943,526	84,660,000,000
1890-1	456,841	19,900,000,000
1-2	317,263	13,820,000,000
2-3	1,116,162	48,620,000,000
3-4	850,780	37,060,000,000
4-5	1,317,263	57,380,000,000
5-6	786,960	34,280,000,000
6-7	674,701	29,390,000,000
7-8	34,894	1,520,000,000
8-9	58,080	2,530,000,000
9-0	372,819	16,240,000,000
1900-1	259,871	11,320,000,000
1-2	395,087	17,210,000,000
2-3	224,058	9,760,000,000
3-4	635,216	27,670,000,000
4-5	281,221	12,250,000,000
5-6	395,087	17,210,000,000
6-7	530,073	23,090,000,000
7-8	149,908	6,530,000,000
Totals	21,080,570	918,270,000,000
Seasonal Averages	602,302	26,236,285,714

This method would be exact and beyond question if we could rely absolutely on the accuracy of the discharge measurements as given on page 12 and the discharge curve plotted therefrom. But there are four factors which should be considered which affect the accuracy of these data:

First—The Geological Survey rating table is only reliable up to 10 feet on the gage or an elevation of 106.43. At this level the right bank of the stream is overflowed and there is no possibility of determining accurately either the area of the section or the velocity of the discharge.

Second—Siegler Creek, which empties into Cache Creek, about 300 feet below the gaging station sometimes discharges a very large volume of water, actually raising the level in Cache Creek and causing the flow to set back into the Lake, reversing the direction of the current at the gaging station.

While this condition is reported to be of comparatively short duration, it undoubtedly has a very considerable influence in retarding the discharge from the Lake. In addition to this, Siegler Creek frequently carries down and discharges into the bed of Cache Creek a large quantity of gravel, thereby forming a bar and retarding the flow.

Third—It is a well attested fact that several times during the past twenty-five years, the residents in the vicinity of Lower Lake, conceiving the idea that their property would thereby be subjected to less damage by overflow, have cleaned out the channel of Cache Creek so as to increase the rate of discharge from the Lake. While it is probably true, as maintained by the Geological Survey, that the channel has been fairly permanent since 1901, the effect of such changing of the channel, prior to that date, should be considered in applying the discharge curve to the mean monthly Lake levels from 1874 to 1900.

It is most natural to suppose that such changes would be made during a period of low water, following a season of unusually heavy rainfall and run off, and the result would be that the total volume of discharge would be very much greater in the following season than that indicated by the rise of the Lake or the mean monthly Lake levels. This would be particularly true if the season following the change were one of light rainfall and run off, as the relative effect on the discharge would be greater and the probability of a bar being formed by the discharge from Siegler Creek less.

Fourth—By referring to "Plate A" it will be noted that the discharge curve as used in determining the quantities on page 12 has been projected four feet above the highest mean monthly gage height reported by the Geological Survey, viz: Elevation 106.78 for April, 1907. This is the highest mean monthly level for which the discharge is given. This mean height is above the right bank of the stream and as the maximum height during this month was 108.18, it is probable that the total discharge during this month was equal to that shown by the curve, or even greater, but it

is impossible to determine with any degree of certainty from the data at hand, the actual rates of discharge between levels 106.43 at which the right bank of the stream is overflowed and the highest recorded level of 111.31 which occurred in March, 1890.

The actual rate of discharge between these levels is purely conjectural and while it is possible that it equals or even exceeds that indicated by the curve as projected, it is equally probable it would be more correctly represented by the dotted straight line drawn tangent to the curve, and at 45° with the axes.

It will be seen, therefore, that the volume of water entering the Lake each season as determined by the discharge curve, based upon the records of the gaging station, is probably excessive for the years of large rainfall and deficient for years when rainfall was light, and that these figures need some correction in order to establish the actual volume of intake more exactly.

But taking the records just as they stand, the average discharge for the past 35 years has been 26,236,000,000 cubic feet per annum, and as a continuous flow of 500 cubic feet per second would be only 15,786,000,000 cubic feet for 12 months, *the continuous operation of a 500 second foot plant is contingent only on the storage capacity of the Lake, and the additional supply which will be available from other sources.*

It should be kept in mind considering the foregoing figures that they all represent volumes of actual discharge or of intake over and above evaporation so that no deduction for evaporation is needed, further that they do not include the discharge of Siegler Creek which it is proposed to turn into the Lake above the impounding dam, so that its yield will be added to the storage capacity of the Lake. There are no records of the flow of Siegler Creek, but, as has already been noted, it is known to discharge at times a very large volume of water.

STORAGE CAPACITY OF THE LAKE.

The exact height to which the impounding dam should be raised can only be determined by careful surveys, but as the Lake has reached an elevation of 111.30 without damage to the surrounding country, it will probably be found that the crest of the dam can be raised to an elevation of at least 110.0. The lowest recorded level of the Lake is 97.73 so that a rise and fall of 12 feet or between 98.0 and 110.0 would be well within the limits of safety and comfort for all concerned.

The average area of the Lake within these limits is 67.096 square miles and the reservoir 12 feet deep would contain 22,446,000,000 cubic feet of water.

EVAPORATION.

In considering the use of this water it will be necessary to take the evaporation into account.

The monthly evaporation from the water surface of the Lake as observed by the U. S. Geological Survey for the years 1901-1905 inclusive is given as follows:

EVAPORATION IN INCHES.

	1901	1902	1903	1904	1905	Averages.
Jan.	0.85	0.85	0.50	0.95	0.60	0.75
Feb.	0.95	0.25	0.80	0.35	0.90	0.65
March	2.40	1.60	0.65	0.50	1.05	1.24
April	3.05	2.60	2.18	1.95	2.45	2.45
May	3.70	4.00	5.12	4.60	3.45	4.17
June	3.95	4.65	5.25	7.00	6.50	5.47
July	5.15	6.65	6.33	7.45	7.70	6.65
Aug.	5.00	4.40	7.00	7.15	7.25	6.16
Sept.	3.35	4.10	5.12	4.85	5.95	4.67
Oct.	2.30	1.95	2.65	2.05	3.10	2.41
Nov.	0.85	0.45	1.07	1.25	1.30	0.98
Dec.	1.30	0.40	0.92	0.75	0.95	0.86
Totals	32.85	31.90	37.59	38.85	41.20	36.48

Taking the average of 36.46 inches for the five years we find the total volume of water evaporating from the Lake in 12 months to be 5,683,000,000 cubic feet. This together with the draft of 15,768,000,000 cubic feet which would be produced by the continuous 500 second foot flow, would make a total consumption of 21,451,000,000 cubic feet for the year. So that assuming the reservoir to be full at any given high water period, the maximum draft of 500 second feet together with the average evaporation for an entire year would lower the water level less than 12 feet even if no water from any source enters the Lake during the entire period.

This is of course a condition which has never obtained and in a great majority of years the Lake would not have fallen below 104.0.

MINIMUM YIELD OF THE LAKE.

It is not, however, the isolated year of small intake, or even of no intake at all, that needs to be particularly considered. Such years are generally preceded or followed by years of abundant intake and the storage capacity of the Lake is ample to take care of them. An examination of the tabulated volumes of intake on page 12 shows at once that a continuous flow of 500 second feet could have been maintained from the reservoir for the entire period covered by the records with the exception of the two seasons of 1897-8 and 1898-9 when the total intake in the 23 months from Nov. 15, 1897, to Oct. 15, 1898, appears to have been very small.

As has already been pointed out it is probable that the intake during this period was considerably greater than here indicated, and that the small rise in the Lake level for each of these seasons and the low mean level over the entire period was caused by the coincidence of the clearing out of

the channel of Cache Creek in the late summer of 1897 and two successive seasons of unusually light rainfall. But assuming that these figures are correct and that the storage capacity of the Lake was limited to 12 feet or from elevation 110.0 to elevation 98.0 we would have had the following conditions.

The total intake for the season 1896-7 was 29,390,000,000 cubic feet of this 25,770,000,000 cubic feet came in on the rise of the Lake from November, 1896, to April, 1897, the balance during the fall of the Lake from April to November, 1897. The high water level in 1897 was reached in April, as the date is not given it is assumed to be about the middle of the month. The rate of intake from November, 1896, to April, 1897, was so greatly in excess of a 500 second foot draft that the Lake would have filled to elevation 110.0 some time in March, 1897, and the excess water flowing over the dam, or through the outlet pipes, could have been counted on to supply the 500 cubic feet per second to the ditch and flume until the end of April (probably for 15 to 20 days longer), leaving the reservoir full at elevation 110.0 on that date.

Passing to the rise in the Lake, November, 1899, to March, 1900, we find the intake to be 14,968,000,000 cubic feet in the five months or at the average rate of approximately three billion cubic feet per month, more than twice the draft produced by a 500 second foot flow.

Assuming again (as the day is not given) that this rise did not begin until the end of November, 1899, there would have been a period of 30 months from May 1, 1897, to November 30, 1899, with the following conditions:

Reservoir full May 1, 1897, containing	22,446,000,000 cu. ft.
Intake during fall of Lake, May 1, 1897, to November 15, 1897,	3,620,000,000 cu. ft.
Intake Nov. 15, 1897, to Nov. 15, 1898,	2,400,000,000 cu. ft.
Intake Nov. 15, 1898, to Nov. 30, 1899,	3,910,000,000 cu. ft.
Total water available,	32,376,000,000 cu. ft.

$$\frac{32{,}376{,}000{,}000}{60 \times 60 \times 24 \times 30 \times 30} = 416 \text{ cubic feet per second.}$$

The seasonal intakes for 1897-8 and 1898-9 used in the above computations are somewhat greater than those computed by the discharge curve and mean monthly Lake levels for the reason that in both of these seasons the Lake level fell below the level of the outlet and no discharge occurred for several months. (This of course assuming that the outlet was then at the same elevation that it has been since the establishment of the gaging station.)

The intakes of 2,400,000,000 and 3,910,000,000 respectively, were therefore determined by deducting from the total volume of intake on the

rise of the Lake, the excess of evaporation over the intake during the fall of the Lake. The latter was determined by plotting the theoretical curve through which the Lake would fall, if acted on only by gravity, subject to no evaporation and receiving no intake during the fall, and finding that in both seasons the Lake reached a level approximately 1.30 feet below the curve, thus indicating that the evaporation had been sufficiently in excess of the intake during the fall to lower the Lake 1.30 feet.

This curve of theoretical fall may be easily and accurately plotted from the rating table or the discharge curve "Plate A."

It will be seen, therefore, applying the extremely conservative discharge measurements of the Geological Survey, to the worst conditions shown by the records of the past 35 years that a flow of 416 second feet could have been maintained from the Lake for the 30 months covering the dryest period on record, and that at all other times in the 35 years a flow of 500 second feet would have been available. This is the supply which can be depended on from the Lake itself without counting the flow in Siegler Creek or the development of any storage, other than the Lake itself, in the Clear Lake catchment area, though several auxiliary storage reservoir sites in this basin are available at small cost; nor does it contemplate the use of the artesian well supply which is known to exist in the basin, a considerable portion of which probably has its origin in other drainage areas.

ADDITIONAL WATER SUPPLY ALONG LINE OF CONDUIT.

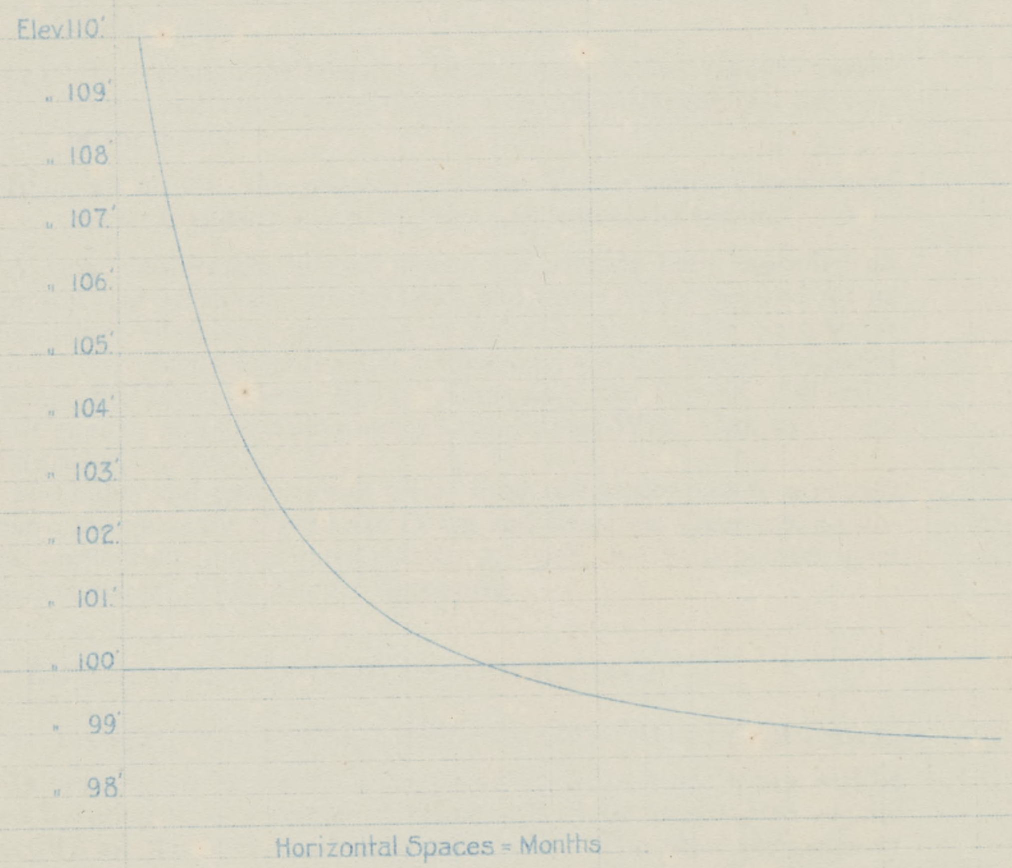
Between the impounding dam at the Lake and the forebay reservoir at the Rumsey Power House there is a drainage area of approximately 85 square miles tributary to the line of the conduit. The rainfall on this area is considerably greater than the average rainfall on the Clear Lake basin owing to the topographical conditions which have already been noted, and it is safe to assume that even in the dryest seasons, an additional supply of 85 second feet can be obtained from this source and in most years a very much greater amount. A few inexpensive dams and ditches in the ravines crossed by the conduit will make the greater part of this supply available when it is most needed, the excess waters which can not be thus stored being used to run the plant as long as possible, leaving the Lake and two main storage reservoirs full at the latest possible date. It is probable that the excess water from this lower drainage area, together with the excess water from the Lake (after it has filled to elevation 110.0) can be counted on at the beginning of a dry season, to operate the plant for a period of from 30 to 45 days.

AUXILIARY STORAGE RESERVOIRS.

Two auxiliary storage reservoirs are provided for along the conduit line, one at Morgan Valley where a storage of 750,000,000 cubic feet can be obtained and another at Davis Creek where 500,000,000 cubic feet of water may be stored. While these reservoirs are designed to act prin-

Theoretical Curve through which Clear Lake would fall by gravity without intake from any source and if not subject to evaporation.

Based on Rating table published by the U.S. Geol. Survey in Water Supply and Irrigation Paper No. 213.



To accompany report of
W. A. Cattell,
Consulting Engineer,
San Francisco, Cal.

cipally as emergency reservoirs for use in case of a break in the conduit, they can be depended upon for a certain amount of help in dry seasons.

TOTAL AMOUNT OF WATER AVAILABLE.

A careful examination of the foregoing data leads to the conclusion that at all times during the past 35 years there would have been available for the operation of the Rumsey Power House a continuous flow of 500 cubic feet per second.

PLAN OF PROCEDURE.

Having established the fact that there will be available for the development of power and later for irrigation a continuous flow of 500 second feet by utilizing the storage capacity of Clear Lake, we will next consider the steps necessary to carry out the project.

These are:

(1) To acquire the lands and riparian rights around the shores of Clear Lake and the riparian rights and water rights along Cache Creek.

(2) To construct the necessary dams, canals, flumes, tunnels, power houses and transmission lines for the development and delivery of the power.

(3) To acquire the properties of the Yolo County Consolidated Water Company and to improve and extend the system.

A very considerable sum of money has already been expended on this project and practically all the lands and water rights required for its consummation have been purchased or are now held under contract or option by the Central Counties Land Company, the California Industrial Company, the Cache Creek Electric Company, the Central California Power Company and the Yolo County Consolidated Water Company. All California corporations.

The rights and properties of all of these companies pass to a merger company, known as the Clear Lake Power and Irrigation Company, a California corporation, incorporated March 2, 1908, for $10,000,000 upon the consummation of the Merger Agreement.

(1) RIPARIAN LANDS AND WATER RIGHTS.

(*a*) LANDS AND WATER RIGHTS AROUND CLEAR LAKE.

In order to proide for the variation of the Lake levels which will be caused by using it as a storage reservoir, it will be necessary to acquire practically all the land fronting on the Lake. The total perimeter of the Lake is approximately 79 miles, of which 62 miles have been acquired by the Company by purchase or contract, 12 miles are held by individuals

or corporations entirely friendly to the project and who will co-operate in carrying it out, leaving five miles yet to be acquired by purchase or condemnation.

In acquiring the lands around the Lake necessary to control the riparian rights, the Company has secured a very large additional acreage that will later be of great value for subdivision.

The total acquired to date is 25,697.4 acres of which 6,124.9 acres are owned in fee and 19,572.5 acres are held by contracts. The total cost of this property including principal and interest to January 1, 1909, is $1,687,340.96, of which $779,468.32 has been paid, leaving a balance to be paid of $907,872.64.

Part of the $779,468.32 here noted as having been paid, was paid by notes or other paper, the obligations of which will appear in a later financial statement.

This amount also includes the $53,300 in stock paid to the Yolo Company as noted on page 31.

The total acreage of lands which it will be necessary yet to acquire is estimated approximately at 2,380 and a liberal estimate of the cost of this property is $225,000.

(*b*) WATER RIGHTS AND LANDS ALONG CACHE CREEK.

After tedious litigation extending over many years, the right to use the waters of Cache Creek for irrigation purposes has been determined by the Courts to be vested in the Yolo County Consolidated Water Company. Their rights pass to the C. L. P. & Irrigation Co. under the merger agreement already mentioned.

In addition to this, the C. L. P. & I. Co. has acquired by purchase or has contracts to purchase a large proportion of the lands along the Creek carrying riparian rights, so that practically all properties needed for the absolute control of the water of the Creek for both power and irrigation purposes are owned or controlled by the Company. These lands comprise 15,849 acres and the total cost to the Company of acquiring these properties including principal and interest on the contracts to January 1, 1909, is $184,506.86. Of this amount, $20,213.50 in principal and interest has been paid, leaving a balance to be paid of $164,293.36.

(*c*) OTHER LANDS.

Still other lands have been acquired by the Company for various purposes which are not included in any of the foregoing classifications. These comprise some valuable timber and agricultural lands and the total cost to January 1, 1909, is $61,393.00, of which $28,593.00 has been paid, leaving a balance due of $32,800.

These lands contain some fine timber which will enable the Company to regulate the cost of lumber for its own construction and also several storage reservoir sites which will be of value in the future.

SUMMARY OF LANDS.

	Acres.	Total Cost to Jan. 1, 1909, Prin. and Int.	Amount Paid.	Balance to be Paid.
Lake Lands Acquired	25,697.4	$1,687,340.96	$779,468.32	$907,872.64
Lake Lands to be Acquired	2,380.0	225,000.00	....	225,000.00
Cache Creek Lands	15,849.4	184,506.86	20,213.50	164,293.36
Other Lands	6,355.0	61,393.00	28,593.00	32,800.00
Totals	50,281.8	$2,158,240.82	$828,274.82	$1,329,966.00

(2) POWER DEVELOPMENT AND TRANSMISSION.

AVAILABLE HEADS.

The development of the maximum amount of power which can be obtained from the water flowing from Clear Lake necessitates the construction of two separate power houses, one at Rumsey, 25 miles from the outlet of the Lake, and the other at Capay, 20 miles below Rumsey, or 46 miles from the Lake.

The elevation of high water in Cache Creek opposite the Southern Pacific Railway station at Rumsey is 420′ and of the Lake (at elevation 98.0 on Mr. Hall's datum) 1324′. The total drop of Cache Creek in the 26 miles is therefore 904 feet.

With an average slope of 4½ feet per mile for the entire conduit, there will be an effective head at the Rumsey Power House of 750 feet.

The fall of Cache Creek in the 20 miles from Rumsey to Capay is 220 feet. The Capay conduit will be an open ditch, of large dimensions, with a slope of 2½ feet to the mile, and the effective head for the Capay Power House will be 160 feet.

The minimum flow at Rumsey will be 500 second feet and at Capay 600 second feet, and assuming 80 per cent efficiency from the falling water to the wheel shaft, we will have:

Rumsey Plant—

$$\left.\begin{array}{l}\text{Horse power}\\ \text{on wheel shaft}\end{array}\right\} = \frac{500 \times 750 \times 62.5 \times 0.8}{550} = 34{,}090$$

Capay Plant—

$$\left.\begin{array}{l}\text{Horse power}\\ \text{on wheel shaft}\end{array}\right\} = \frac{600 \times 160 \times 62.5 \times 0.8}{550} = 8{,}727$$

Total 42,817

This is the continuous power which the available water would produce in the two plants even in the dryest years.

It is of course impossible in actual practice to produce and sell power at a uniform rate from day to day or throughout the 24 hours. The load on any given plant varies greatly, the average load frequently being but 50 or 60 per cent of the maximum capacity of the plant.

As there seems to be still much confusion even among engineers and power manufacturers, in the use of the terms employed in the production and measurement of power, it may be well to review them briefly here, that there may be no misunderstanding as to their use in the following discussion.

DEFINITION OF TERMS.

The measurement of power necessarily involves the element of time.

A mechanical horse power, is the energy required to raise a weight of 33,000 pounds one foot in one minute, or 550 pounds one foot in one second.

A Kilowatt, which is the measure of electrical energy, is approximately the equivalent of $\frac{4}{3}$ of a horse power or 1 H. P. $= \frac{3}{4}$ K. W.

The load factor for a given power plant is the ratio of the average load which it carries to the maximum power it can produce, or the total output in H. P. or K. W. hours for a given period, divided by the total H. P. or K. W. hours it could produce if operated continuously, at its maximum capacity for the same period.

Thus a plant capable of producing 100 H. P. would deliver, if operated continuously at its maximum capacity for 24 hours, 2400 H. P. hours; but if during the 24 hours the total output was only 1200 H. P. hours, the load factor on the plant would be 1200 divided by 2400, or 50 per cent.

The limit of the power which can be produced by a hydro-electric plant, is determined by the total *amount* of water available, and the *rate* at which this water can be delivered at the power house.

The capacity of plants dependent upon the natural flow of a stream, without storage or regulation, will fluctuate directly with the stream flow, and while the total output in H. P. hours per annum of such a plant might be very high, if sufficient machinery were installed to utilize the maximum flow, its commercial value would be small, as the output would be limited at times by a very small stream flow, which perhaps might cease altogether.

With proper storage and regulation which would permit the same volume of water to be used as desired, the commercial value of the plant would be increased many fold.

In order to derive the greatest possible revenue from the water from a given watershed it is necessary to consider carefully the maximum, minimum and average yield, the amount which may be stored, the cost of storage, the probable character of the loads to be carried, the load factor, and the relations between costs and capacities, of conduits and power houses.

If it were established that the minimum yield of a given watershed, with proper storage and regulation, was, say 500 second feet continuously through a long term of years, and that this water would produce, say, 40,000 continuous horse power—that this amount of water could be delivered at the power house at the rate of 500 second feet continuously, or at the rate of 1000 second feet for half the time, and if it were further

known that the load factor on the power plant would be but 50 per cent. it would be manifestly absurd, if there was a market for all the power that could be produced, to install a 40,000 H. P. plant and operate it on a 50 per cent load factor, thus wasting one half of the available water. Theoretically we would install an 80,000 H. P. plant which when operated on a 50 per cent load factor would utilize all the water and produce the greatest possible revenue from the sale of power.

This of course is a purely hypothetical case and is given here merely for the sake of illustration. No such perfect regulation in the use of water, as is here assumed could be obtained in actual practice, but the maximum earning capacity of a power plant will be found somewhere between the above extremes.

AMOUNT OF POWER TO BE DEVELOPED FROM CACHE CREEK.

In order to develop the greatest possible commercial value from the water available at Rumsey it is proposed to build the Rumsey conduit with a carrying capacity of 600 second feet and to provide sufficient storage capacity in the forebay reservoir at the Rumsey Power House to supply an additional 100 second feet to carry the peak load for one or two hours per day.

The peak capacity of the plant would then be:

$$\left.\begin{array}{r}\text{Horse power}\\ \text{on wheel shaft}\end{array}\right\} = \frac{700 \times 750 \times 62.5 \times .8}{550} = 47{,}727 \text{ H. P.}$$

Assuming that the plant would carry manufacturing, dredger, and railroad loads for 18 hours out of each 24, requiring the use of 400 second feet of water, and that during the remaining 6 hours the additional lighting load and railroad peak load would require the use of 600 second feet of water, with a possible peak for one hour requiring 700 second feet, the total horse power hours delivered each day would be:

(400 sec. ft.) = 27,272 H. P.	for 18 hours	=	490,896 H. P. hours.
(600 sec. ft.) = 40,909 H. P.	for 5 hours	=	204,545 H. P. hours.
(700 sec. ft.) = 47,727 H. P.	for 1 hour	=	47,727 H. P. hours.
Total			743,168 H. P. hours.

The average power produced would be:

$$\frac{743{,}168}{24} = 30{,}965 \text{ H. P.}$$

and the load factor on the plant would be:

$$\frac{30{,}965}{47{,}727} = 65 \text{ per cent}$$

The water consumed would be:

400 sec. ft. for	18 hours	=	7,200
600 sec. ft. for	5 hours	=	3,000
700 sec. ft. for	1 hour	=	700
			10,900

Or an average for the 24 hours of 454 second feet.

There would therefore be an abundance of water to carry such a load and to provide for imperfect regulation of water on the wheels.

These figures are here given not as final, but as indicating the possibilities in the use of the water and the reasonable and conservative basis on which the estimates of cost and earnings are made.

After passing the wheels of the Rumsey Power House, the water will be discharged into the conduit leading to the Capay Power House. This conduit will be about 20 miles in length, and there will be an effective head at Capay of 160 feet.

It is entirely practicable to take an additional supply of at least 100 second feet into this conduit from the natural flow of Cache Creek, at Rumsey, during the greater part of each year. By the development of the storage possibilities along the North Fork of Cache Creek, which will be necessary for the full development of the irrigation features connected with this project, this additional supply will be available at all times of the year, in the dryest seasons. In fact a very much larger flow could be made available for power at the Capay Plant if the North Fork storage were utilized for power only, but it will probably be found more profitable, considering the comparatively low head at the Capay Plant, to reserve all of the North Fork storage for irrigation. This water would be running for irrigation purposes in the late summer and fall months, when the natural flow of the stream would be less than 100 second feet so that there will always be available for power in the Capay Plant, a flow of 600 second feet.

The continuous power which this would produce would therefore be:

Horse power on wheel shaft =

$$\frac{600 \times 160 \times 62.5 \times .8}{550} = 8{,}727 \text{ H. P}$$

It will probably be found expedient to give the Capay conduit a carrying capacity of 750 second feet as this capacity will be ultimately required for irrigation purposes, but it is not contemplated that any storage will be provided in the forebay reservoir at Capay to carry a peak load, as will be the case at Rumsey. The loss from seepage and evaporation in the Capay conduit will be considerably greater than in the Rumsey conduit. It is therefore estimated that except during the irrigation period when sufficient water is entering the Capay conduit at Rumsey from the Rumsey Power House and the North Fork storage combined to make the total volume reaching the Capay Plant 750 second feet, the maximum volume

which will be available for power in the Capay Power House will be the 700 second feet from the Rumsey Power House, plus the steady 100 second feet from the natural flow of Cache Creek, less a loss from seepage and evaporation of 10 per cent, or 720 second feet.

Figuring the Capay Plant on the same basis as that used for the Rumsey Plant, the maximum peak capacity at Capay would be:

$$\left.\begin{array}{l}\text{Horse power}\\ \text{on wheel shaft}\end{array}\right\} = \frac{720 \times 160 \times 62.5 \times .8}{550} = 10{,}472 \text{ H. P.}$$

The total Horse Power Hours each day would be:

				H. P. Hrs.
(400+100) — 10% = 450 sec. ft. =	6,545 H. P.	for	18 hrs. =	117,810
(600+100) — 10% = 630 sec. ft. =	9,163 H. P.	for	5 hrs. =	45,815
(700+100) — 10% = 720 sec. ft. =	10,472 H. P.	for	1 hr. =	10,472
Total				174,097

The average power produced would be:

$$\frac{174{,}097}{24} = 7{,}254 \text{ horse power.}$$

The load factor would be:

$$\frac{7{,}254}{10{,}472} = 69 \text{ per cent.}$$

The water required to produce this power in the Capay Plant would be:

450 sec. ft. for 18 hours =	8,100
630 sec. ft. for 5 hours =	3,150
720 sec. ft. for 1 hour =	720
Total	11,970

$$\frac{11{,}970}{24} = 499 \text{ sec. ft. average.}$$

The average flow available to supply this demand would be the average of 454 second feet discharged by the Rumsey Power House plus 100 second feet from Cache Creek less a 10 per cent loss, or 499 second feet.

This coincidence of figures is merely incidental but as the loss assumed of 10 per cent is high there would be an abundance of water.

The total continuous power developed on the wheel shaft by the two plants and the total horse power hours they will produce on the foregoing basis will therefore be:

	Continuous H. Power.	H. P. Hrs. per Day.	H. P. Hrs. per Annum.
Rumsey Plant	34,090	743,168	271,256,320
Capay Plant	8,727	174,097	63,545,405
Totals	42,817	917,265	334,801,725

The total of 334,801,725 H. P. hours per annum is the equivalent of 251,101,294 K. W. hours per annum, and assuming a total loss in generators, transformers and transmission line of 20 per cent, there would be for sale at the end of the transmission line say 200,000,000 K. W. hours per annum.

As the total length of the transmission line from the Rumsey Power House to San Francisco would be but 85 miles and as the more recent California Plants using 100,000 volts pressure are now transmitting power from 140 to 150 miles with losses from the wheel shaft to step down transformers at the end of the transmission lines of but 15 per cent, the 20 per cent loss assumed is very high and it is safe to estimate that 200,000,000 K. W. hours of actual energy can be delivered and sold each year.

The load factors of 65 per cent for the Rumsey Plant and 69 per cent for the Capay Plant, developed in the foregoing computation should not be confused with the low load factors which are sometimes shown for Hydro-electric plants, by dividing the actual energy sold by a total *connected* load, which is frequently from 1 2/3 to 2 1/2 times the maximum capacity of the plant.

ESTIMATED COST OF CONSTRUCTION..

The construction work necessary for the production and delivery of the power as above outlined, may be generally segregated as follows:

Impounding Dam at Clear Lake.
Improvement of Cache Creek Channel.
Diverting Dam.
Rumsey Conduit.
Rumsey Power House.
Capay Conduit.
Capay Power House.
Storage Reservoirs.
Transmission Line.

IMPOUNDING DAM.

There are two excellent sites available for the location of this dam near the outlet of the Lake, both have been examined by borings, and a firm clay is found a few feet below the surface of the ground, at each site.

Several types of dam have been considered, the most efficient and economical structure at this point will probably be found to be an earth embankment with concrete core wall, which together with the concrete spillway and outlet works, will rest on piling driven well into the clay.

The total cost of this dam, including spillway, gates and regulating devices and the dredging on the Lake side necessary to provide proper approaches to the outlet, will not exceed $50,000.

IMPROVEMENTS OF CACHE CREEK CHANNEL.

To provide for the discharge of the maximum volume of flood waters which may come after the Lake is full to elevation 110.0 and also to

provide a suitable channel for conducting the water from the impounding dam to the diverting dam, it will be necessary to enlarge and improve the channel of the creek between these points, a distance of about four miles. This work will cost $20,000.

RUMSEY CONDUIT.

The main conduit from the diverting dam to the Rumsey Power House will be 22 miles in length. Of this 55,600 lineal feet will be ditch and flume; 57,000 feet tunnel and 6000 feet reinforced concrete trestle.

The cross sections and gradients, of both ditches and tunnels, will be varied to suit the configuration of the ground and the nature of the material penetrated. In general the ditch will be 10 feet wide at the bottom, 6 feet deep and with side slopes of 1 to 1. The tunnels will have an average cross section of about 75 square feet requiring the removal of about 3 cubic yards of material per lineal foot of tunnel.

The smaller tunnels at the upper end of the conduit are through shale, serpentine, cemented gravel and earth, and will be lined with concrete. The longer tunnels which are at the lower end of the conduit, are almost entirely through firm sandstone rock which will need no lining. Less than one-half of the entire length of tunnels will require lining.

The construction of this conduit presents no special engineering difficulties and the total cost of the entire 22 miles with ample allowance for engineering and contingencies will not exceed $2,000,000.

RUMSEY POWER HOUSE.

The Rumsey Power House will be of steel frame, covered with corrugated iron on concrete foundations, and will contain four complete generating units of 7500 K. W. capacity each and will cost complete $650,000.

The location of this power house is particularly favorable for cheap and rapid construction as it is located within three-quarters of a mile of the Rumsey Station of the Southern Pacific Company, thus avoiding the great expense which most of the Hydro-electric plants in California have experienced, in the construction of costly mountain roads and a long team haul for all materials and machinery.

CAPAY CONDUIT.

The conduit will be 20 miles in length, following for a considerable portion of this distance a ditch formerly used by the Yolo County Consolidated Water Company. Practically the whole length of this ditch will be in open cut, through good material which can be readily removed by a steam shovel at small unit cost. The total estimated cost of this portion of the work is $240,000.

CAPAY POWER HOUSE.

The Capay Power House will be similar in construction to the Rumsey Power House and will contain one generating unit of 7500 K. W. capacity. The total estimated cost, including the building and all appurtenances, is $150,000.

STORAGE RESERVOIRS.

Two storage reservoirs are provided for along the line of the Rumsey conduit, one at Morgan Valley with a storage capacity of 750,000,000 cubic feet, and another at Davis Creek with a capacity of 500,000,000 cubic feet. These reservoirs present no difficulties in the way of construction. Ordinary earth dams with concrete core walls will impound the waters. These dams together with the regulating gates and all operating machinery will cost, complete, $95,000.

TRANSMISSION LINE.

The transmission line will be constructed with steel towers of the most substantial character and will extend from the Rumsey Power House to Oakland, a total distance of 80 miles, thence by cables under the Bay to the City of San Francisco. The total cost of the transmission line, including substations and step-down transformers, will not exceed $850,000.

In all of the foregoing estimates a liberal allowance is made for engineering and contingencies. The total cost of the construction work involved in the development and transmission of power will therefore be as follows:

SUMMARY OF ESTIMATED COST OF CONSTRUCTION.

Impounding Dam	$ 50,000
Deepening Cache Creek	20,000
Diverting Dam	30,000
Rumsey Conduit	2,000,000
Rumsey Power House	650,000
Capay Conduit	240,000
Capay Power House	150,000
Storage Reservoirs	95,000
Transmission Line	850,000
Total	$4,085,000

(3) YOLO COUNTY CONSOLIDATED WATER COMPANY.

(Irrigation System.)

The property of this Company consists of three ditch systems known respectively as the Moore, Capay and Adams.

MOORE DITCH.

The Moore ditch takes water from Cache Creek at a point 3½ miles East of Madison, where the Company owns 55 acres of land and has erected a permanent dam costing $10,000. From this dam there is a ditch 4 miles long, and 20 feet wide at the bottom, with a grade of 3 feet per mile, capable of carrying 150 second feet. Also 12 miles of ditch, 12 feet wide on the bottom, and approximately 150 miles of lateral distributing ditches.

CAPAY DITCH.

The Capay Ditch takes its water from Cache Creek about 12 miles above the Moore Ditch. It has no permanent dam but has 20 miles of 20 inch ditch, 12½ miles of 12 inch ditch and 4½ miles of 10 inch ditch together with 20 miles of natural slough and 50 miles of laterals.

ADAMS DITCH.

The Adams Ditch starts 1¾ miles below the Capay Ditch on the opposite side of the creek and has 16 miles of 20 inch ditch, 6 miles of natural slough and 10 miles of laterals. The Adams Ditch has no permanent dam.

The three systems combined have a total of main ditches and laterals as follows:

	Main Ditches.	Laterals.
Moore Ditch,	16 miles	150 miles
Capay Ditch,	57 miles	50 miles
Adams Ditch,	22 miles	10 miles
Totals,	95 miles	210 miles

The main ditches have an average capacity of 150 sec. feet each or a total of 450 sec. feet, which can be increased to 600 sec. feet at small cost when the additional and regulated supply which will be secured by the construction of the Clear Lake dam is available.

The above system of ditches now irrigate approximately 10,000 acres of farm land, all in Yolo County. This acreage has increased at the rate of about 1,000 acres per year since 1903. The average annual revenue received from sale of water has been as follows:

	Acres Irrigated.	Revenue.	Revenue per Acre.
1903	5,000	$ 8,771.49	$1.75
1904	6,000	7,865.90	1.31
1905	7,000	8,672.59	1.24
1906	8,000	11,732.39	1.47
1907	9,000	11,413.92	1.27
1908 (6 mos.)	10,000	16,071.89 (6 mos.)	1.61

This revenue has been obtained notwithstanding the fact that the Company could not furnish water when it was most needed. With suffi-

cient supply and proper regulation the average revenue per acre would be at least $2.00 per annum.

The following statement shows the full financial operations of the Company from January 1, 1903, to June 30, 1908. The gross earnings are from the sale of water. The operating expenses include all salaries, attorneys' fees, taxes and the amounts expended in the construction of temporary dams. It should be noted that the figures for 1908 are for six months only—from January 1st to June 30th.

Year.	Gross Earnings.	Operating Expenses.	Fixed Charges.	Surplus.	Deficit.
1903	$ 8,771.49	$ 6,327.00	$ 1,318.40	$1,126.09	....
1904	7,865,90	6,597.13	9,268.12	....	$ 7,999.35
1905	8,672.59	8,925.55	11,957.59	....	12,210.55
1906	11,732.39	11,872.10	11,753.45	....	11,893.16
1907	11,413.92	10,243.06	10,790.35	....	9,619.49
1908 (6 months)	16,071.89	6,171.52	5,833.24	4,067.13	....
Totals	$64,528.18	$50,136.36	$50,921.15	$5,193.22	$41,722.55
Less Surplus					5,193.22
Net Deficit					$36,529.33

This would give the totals for the period from Jan. 1, 1903, to June 30, 1908, as follows:

Total gross earnings,	$64,528.18
Operating Expenses,	50,136.36
Net Earnings,	$14,391.82
Bond Interest,	50,921.15
Net Deficit,	$36,529.33

The 95 miles of main ditch, together with the permanent dam for the Moore ditch and 491 acres of land and the rights to some 13½ miles of swamp and overflow lands along the shores of Clear Lake represents an expenditure according to the Company's statement, of $565,718.06, as follows:

Cottonwood Ditch, July, 1864........	$ 7,000.00
Cottonwood Ditch, July, 1867........	8,000.00
Capay Ditch, April 29, 1879..........	23,666.00
Adams Ditch Co., Feb. 18, 1903.......	80,000.00
Moore Ditch Co.	95,000.00
Extending Capay Ditch	90,499.68
Extending Adams Ditch	50,341.88
New dam and extending Moore Ditch...	62,115.03
Lake County Lands	23,686.00
Spring Valley property.............	25,000.00
	$465,308.59
Improvements since 1903	100,409.47
Total plant account.........	$565,718.06

In 1905 the Department of the Interior caused the Yolo County Consolidated Water Co. to be investigated by Mr. Lippincott, Engineer of the

Reclamation Service and Hon. E. A. Hitchcock, Secretary of the Department in a letter dated January 15, 1905, states that Mr. Lippincott placed a value on the foregoing property of $516,866.00.

Under the contract existing between Mr. E. P. Vandercook and the corporations and individuals whose interests are now merged in the Yolo Co. Con. Water Co., the entire capital stock of the Yolo Company is to be delivered to Mr. Vandercook for $502,050.00, subject to the $225,000.00 of bonds now outstanding on the Yolo Company.

The $502,050.00 is to be paid as follows:

$161,250.00 in cash, $53,300.00 in stock (par value) of the Central Counties Land Co. and $287,500.00 in bonds (par value) of the Central California Power Company.

As the $53,300.00 was considered as issued to the Yolo Co. in payment for lands around the Lake, the amount is deducted from the total in the tabulation on the next page and added to the totals in the Summary of Lands, under Lake Lands on Page 27.

Of the foregoing, $61,250.00 has been paid in cash. The 533 shares of stock in the Central Counties Land Co. has been issued and delivered and the $287,500.00 of bonds of the Central California Power Company have been issued and placed in escrow with the California Safe Deposit and Trust Company.

Under the contract aforesaid, interest at the rate of 5 per cent per annum accrues on the unpaid purchase price. Of such interest, $16,641.50 has already been paid and $16,641.50 additional was due January 1, 1909.

In addition the purchaser guarantees the interest on the Yolo County Consolidated Water Company's bonds and has already paid $13,444.37 of such interest. Of the total of $30,085.87 in interest on contract and the Water Company's bonds, $10,515.12 has been paid in cash and $19,570.75 by notes. Additional interest on the bonds to the amount of $8,437.50 was due on January 1, 1909. The account under the contract, on January 1, 1909, stood as follows:

	Total Contract Price.	Paid. Principal.	Paid. Interest.	Total Paid to Jan. 1, 1909
Cash,	$161,250.00	$ 61,250.00	$16,641.50	$ 77,891.50
Bonds,	287,500.00	287,500.00		287,500.00
Totals on Contract,	$488,750.00	$348,750.00	$16,641.50	$365,391.50
Interest on Yolo Co. Cons. Water Co. Bonds,			$13,444.37	$ 13,444.37
Balance due January 1st, 1909:				$378,835.87
Principal,			$100,000.00	
Interest			16,641.50	
Total on Contract			$116,641.50	
Interest on Yolo Co. Con. Water Co.'s Bonds,			8,437.50	
Total due Jan. 1, 1909,			$125,079.00	$125,079.00
Grand Total				$503,914.87

The total initial expenditure necessary to improve and extend the present canals to accomplish the sale of water rights on a large scale will not exceed $200,000. This would make the total cost of the irrigation system complete, including the $225,000.00 of outstanding bonds, $928,914.87.

IRRIGATION POSSIBILITIES.

It needs but little investigation to convince anyone of the wonderful field for the development of irrigation in Yolo County. The soil is rich and fertile, the climate admirably adapted to the growing of grain and hay and of many varieties of fruits.

The service heretofore rendered by the Yolo County Consolidated Water Company has been wholly inadequate on account of their inability to regulate the flow of water from Clear Lake, or to deliver the water when it was most needed.

The irrigation possibilities of Yolo County have been carefully investigated and fully reported on by the Government experts, and no better presentation of the matter can be made than in the words of these well-known engineers.

In the report of the Department of Agriculture on "Irrigation Investigations in California," Bulletin No. 100 (1901), Mr. J. M. Wilson, C. E., after describing the Lake and Cache Creek, and the irrigation methods there employed, says, beginning on page 187:

"PRESENT CONDITIONS AND POSSIBILITIES OF YOLO COUNTY."

"With the exception of the few pumping plants described, the Moore ditch holds the field. The capacity of the ditch as managed is utterly inadequate to the demands of the territory covered. Except for those who are most favorably situated, there can be no certainty of obtaining water when desired. When water is most needed there are always more users wanting it than can possibly be served. The lack of certainty, or rather the certainty that all cannot get water, operates to discourage the growing of crops requiring irrigation. The cost of leveling the land and preparing the levees for flooding, which is almost the universal custom here, is not a small item of expense. Unused levees are not only useless, but are impediments to cultivation and harvesting. The water user, disappointed in getting water for lands already prepared, has little encouragement to continue or extend his efforts. The more progressive farmers, who are convinced that the growing of grain is impoverishing the soil and who would gladly change to a mixed husbandry with rotation of crops, are still compelled to grow wheat year after year at a loss. With water these lands will produce four to six crops of alfalfa annually, aggregating five to ten tons per acre. With this alfalfa and the other forage crops that would be possible with an assured supply of water, the growing of cattle

and sheep, the feeding of range stock, and hog raising would all be profitable industries. The possibilities of this section for dairying have been amply demonstrated by the farmers in the vicinity of Woodland and Yolo. The long season that it is possible to keep stock on green feed in this climate when water can be supplied for the irrigation of the pastures makes the conditions here particularly favorable for this and all kindred industries. The only drawback is the lack of water for pasture and for forage crops."

* * * * * *

"We have here a country of marvelous possibilities, a soil rich in all the elements of plant growth, with surface smooth and easy of tillage, a climate whose summer heat and winter cold are tempered by the breezes of the Pacific, so equable that here all the choicest products of the temperate zone and of the subtropics are grown alike in perfection. Here flourish side by side the apple, the peach, the pear, the plum, the apricot, the grape, along with the orange, the lemon, the lime and the fig. Here the oak and the pine, there the palm and the pepper tree. The roses bloom winter and summer. The orange carries its fruit through the winter, the oleander is a tree and the heliotrope a hardy shrub."

* * * * * *

"With rights defined and full protection assured for all the beneficial uses of water and an efficient and prompt distribution to the rightful users, there is no reason why the waters of Cache Creek and Clear Lake should longer run to waste. With the facilities for storage at minimum cost and the unlimited opportunities for the development of power, Lake County has at her hand the opportunity of easy and direct communication by rail and water with the outside world. This would bring an easy market and increased population to her borders and the development of all her agricultural and horticultural resources. The advantages of Lake County as a sanitarium and pleasure resort and as a region for picturesque homes can never be fully realized without easier means of transportation. Cache Creek and Clear Lake have in them the solution of this problem. Nor would the uses for power cease with Lake County. In Rumsey and down Capay Valley and along the foothills bordering the Sacramento Valley there are abundant opportunities for the use of power in putting into more concentrated form the products of this rich farming country, in lighting towns, furnishing power for shops, pumping water for the irrigation of arid lands, the reclamation of swamps, and innumerable other uses—all these without interfering with the use of the water for irrigation or abating its value in developing the unparalleled agricultural and horticultural possibilities of this wonderful soil and climate.

"With proper conservation and distribution of the waters that now go to waste in Cache Creek and such subdivision of the lands as would make possible even a moderate realization of her great natural resources, Yolo County ought to furnish independent homes and maintain in comfort and with much of luxury a rural population of many times what she now

supports and make of each of her towns a thriving center of trade and manufacture and of social and intellectual life."

Such statements indicate very clearly the possibilities in the use of the waters flowing from Clear Lake for irrigation purposes.

Mr. Samuel Fortier, Irrigation Engineer for the Department of Agriculture, in charge of the Pacific District, writing under date of June 11, 1907, is even more explicit as shown by the following letter and paper:

[COPY.]

UNITED STATES DEPARTMENT OF AGRICULTURE,
Office of Experiment Stations,
Irrigation and Drainage Investigations.

BERKELEY, CAL., June 11, 1907.

MR. E. P. VANDERCOOK,
No. 1016 Broadway, Oakland, Cal.,

Dear Sir: I returned recently from Yolo County, where I learned something of the effort which is about to be made to utilize the water resources of Cache Creek and Clear Lake for irrigation and power purposes.

Last summer we carried on investigations in that part of the Sacramento Valley for our branch of the U. S. Department of Agriculture, and we intend to continue these investigations and extend them to other localities during the present season. Next winter we hope to have material enough to prepare a bulletin on the irrigation conditions and possibilities of the Sacramento Valley.

Meanwhile, I have prepared for the press a brief synopsis of the irrigation possibilities of Yolo County, as brought out by our investigations last summer, and knowing you to be interested in the enterprise, I take pleasure in enclosing you a copy.

Last Friday the Promotion Committee had its semi-annual meeting at Petaluma. The topics discussed were irrigation and forestry. I send you a clipping of a part of my paper on the benefits of irrigation.

If convenient I would like to call upon you some time to learn something more of your contemplated operations in Yolo County in connection with the Yolo County Consolidated Water Company. When at Woodland I was informed that yourself and associates were of the opinion that the best part of the enterprise consisted in the amount of power that might be developed. I would like to impress upon you the possibilities of the irrigation features of the scheme.

Sincerely yours,
(Signed) SAMUEL FORTIER,
Irrigation Engineer, in Charge of Pacific District.

COPY OF PAPER ACCOMPANYING MR. FORTIER'S LETTER OF JUNE 11, 1907.

"Irrigation Possibilities of Yolo County, California.

"Recent investigations made in Yolo County by the Irrigation and Drainage Investigations of the United States Office of Experiment Stations go far in demonstrating that the natural conditions of this part of the Sacramento Valley are unsurpassed as a profitable field for irrigated agriculture. The most favorable conditions are an abundant water supply, a large extent of fertile land and a mild climate tempered by Pacific breezes.

"Cache Creek, the largest Coast Range tributary of the Sacramento River, traverses the county west to east. The discharge of the stream during the rainy season varies all the way from 60,000 to 160,000 acre-feet per month, while in September the flow frequently falls below 10,000 acre-feet. This extreme fluctuation would be a serious drawback to its value as a source of supply were it not for the existence of Clear Lake. This lake has an area at mean water level of over 41,000 acres. The records show that the rise and fall of its water level during the past thirty years has exceeded ten feet, and that the storage capacity between these extremes of high and low water levels is over 400,000 acre-feet. The results of measurements made by the United States Geological Survey at the mouth of the Lake show that the average yearly discharge from the Lake during the four-year period from 1902 to 1905, inclusive, was 384,000 acre-feet. Of this amount nearly 73,000 acre-feet flowed down Cache Creek during the months of June, July, August and September of each year when it might have been wholly diverted and used for irrigation purposes. This would leave a balance of 311,000 acre-feet out of the total yearly outflow to be stored. By the construction of the necessary controlling works at the lower end of the Lake and the excavation of an outlet canal to draw off the water when needed, considerably more than the average discharge during the period when water is not required for crops might be stored for the late summer use.

"Last year the farmers of Yolo County paid taxes on 597,313 acres. Of this about 350,000 acres is tillable land, 130,000 acres grazing lands, and the balance tule or overflow lands. During the past ten years the area devoted to cereal culture has varied from 200,000 to 250,000 acres. The most significant change in that time has been the substitution of barley for wheat and more recently the substitution of both for grain hay. In 1896 there were 160,000 acres seeded to wheat and 16,000 acres to barley, while in 1906, ten years later, there were 84,000 acres seeded to wheat and 150,000 acres to barley. This change, if rightly interpreted, means that the soil, though still fertile, will no longer produce profitable yields of wheat. Soon it will not produce profitable crops of any kind without rotation and the right kind of rotation cannot be extensively introduced without irrigation.

"If this conclusion is correct, the future prosperity of Yolo County

depends mainly on the extension of its irrigated area. Fortunately for the land owners of the county, the irrigated area is not only being rapidly increased, but the canal system from Cache Creek is being extended to cover most of the best land.

"The history of the diversion of water from Cache Creek to the year 1903, a period of 47 years, is little else but a maze of costly and fruitless litigation. On February 16, 1903, all the various interests on the stream were consolidated under the name of the Yolo County Consolidated Water Company, a Corporation, organized with a capital of $1,000,000. This company since its organization has made extensive improvements and extensions on both the Moore and Adams canal systems and has extended the Capay Canal to Winters, a distance of 32½ miles. The Capay and Winters system also comprises some 40 miles of lateral ditches, built by the farmers.

"Investigations made last summer by Mr. J. H. Barber on the use of water under the consolidated system indicate considerable waste of water due to seepage from the ditches, but a fairly economical use on the part of the farmers. About 90 per cent of the irrigated area is in alfalfa and, as a rule, the first two crops can be grown without being irrigated. The average amount of water used on 12 alfalfa fields for the first irrigation was 8½ inches in depth over the surface. Less water was used on the second and third irrigation. The net duty of water for 1906 may therefore be taken at about 2 acre-feet for alfalfa and a less amount for other crops.

"It will be remembered that the average discharge from Clear Lake for a period of four years was 384,000 acre-feet. This does not include such tributaries as Bear Creek or North Creek. Now if this volume of water could be stored and conveyed to the farms without loss it would irrigate 192,000 acres on the basis of 2 acre-feet for each acre, or an average depth over the surface irrigated of 24 inches.

"The present heavy losses due to seepage from the ditches and canals makes a large amount of water necessary. Even when the average amount of water used is increased to 3 acre-feet per acre for the season, there is still sufficient water in the creek when retained in Clear Lake to irrigate 128,000 acres of land. These figures convey some idea of the irrigation possibilities of Yolo County.

"The Cost of Water.

"Water is sold by the Yolo County Consolidated Water Company at a cost of $2 per cubic foot per second for 24 hours. The head mostly used is what is known as a six-foot head, equivalent to twelve cubic feet per second, and costs, therefore, $24 for 24 hours, or $1 per hour. A flow of twelve cubic feet per second for one hour will cover an acre one foot deep, or in other words, will furnish one acre-foot of water. Consequently, the cost of water stated in the most generally acceptable manner is $1 per acre-foot.

"The results of measurements made in 1906 by the U. S. Office of Experiment Stations show that 2.16 acre-feet per acre were used on alfalfa. The cost of water for the season would therefore be $2.16 per acre.

"Many growers irrigate more cheaply than this, the amount of water used depending largely on the thoroughness with which the land has been prepared for irrigation, the skill of the irrigator, the size of the irrigating head and other conditions."

(End of Mr. Fortier's paper.)

Mr. Fortier places the tillable land in Yolo County at 350,000 acres and estimates, that, based on the average duty of water in Yolo County, the waters flowing from Clear Lake would irrigate 192,000 acres. It is therefore safe to assume that with the additional flow from the North Fork which would be conserved by the Clear Lake Power & Irrigation Company, the total area irrigated would be more than 200,000 acres.

Mr. Fortier also gives the cost of water for Yolo County at $1.00 per acre-foot, which for the 200,000 acres, using an average of 2 feet per acre, would produce a gross revenue of $400,000 per annum.

The cost of extending the present system to irrigate 200,000 acres, including the development of the North Fork storage would be met largely from the sale of water rights. The permanent right to use water from an irrigation system, which right goes with the land, is generally sold in California at from $20 to $30 per acre; and it is conservatively estimated that the water rights in Yolo County will bring at least $15 per acre, of which $5 will be applied to the cost of extending main canals, leaving $10 per acre net. It will probably require from three to four years to extend the system so as to irrigate the entire 200,000 acres, but with proper management this might be accomplished in less time.

The cost of rehabilitating the present canals, and extending them so as to enable the Company to render efficient service and begin the sale of water rights, is estimated at $200,000, and this amount is included in the total cost of the Yolo County Consolidated Water Company as included in this project.

MARKET FOR POWER.

The market for power in California, particularly in San Francisco and the surrounding bay district, has recently (purposely and for commercial reasons) been persistently misrepresented, and is therefore very much misunderstood. The writer has had occasion to study this matter very carefully during the past three or four years and has arrived at the conclusion that the demand for power in this section is already greater than the present hydro-electric plants can meet, even including the recent installations of the Great Western Power Company and the Stanislaus Electric Company and the additions to these plants which are now being constructed, or are under consideration; in fact that the combined output of all the hydro-electric plants now operating and which have been projected or are physically and financially feasible, will, in a few years, be entirely

inadequate to supply the demand. The projected plants cannot be constructed rapidly enough to keep pace with the constantly increasing demand for power. It will be found upon careful investigation that this opinion is held by all who are really familiar with, and competent to judge, the situation, and who are sufficiently disinterested and free from bias of corporate interests, to express their real convictions.

A brief consideration of the following facts will indicate the foundation upon which this conclusion is based:

SCHEDULE OF PRESENT HYDRO-ELECTRIC DEVELOPMENTS WITHIN A RADIUS OF APPROXIMATELY 200 MILES FROM SAN FRANCISCO, WITH LENGTH OF TRANSMISSION LINES, AND THE MAXIMUM CAPACITY OF EACH PLANT IN ELECTRICAL HORSE-POWER ON THE SWITCHBOARD.

Name of Company and Plant.	Location.	Length of Transmission Line in Miles. To Oakland.	To S. F.	Maximum Capacity of Machinery Installed, H. P.
California Gas & Electric Company—				
de Sabla	Butte Creek	179	259	17,500
Centerville	" "	174	254	8,600
Colgate	Yuba River	142	222	19,000
Nevada (S. Yuba)	" "	(a)	(a)	1,600
Deer Creek	S. Yuba Water Co.	157	237	7,400
New Castle	Ditch System	112	192	1,075
Alta	" "	151	231	4,000
Auburn	" "	117	197	670
Folsom	American River	106	186	5,000
Electra	Mokelumne River	120	145	26,800
Northern California Power Company—				
Kilare	Cow Creek	270	350	4,000
Volta	Battle Creek	270	350	5,700
Battle Creek	" "	270	350	6,700
Siskiyou E. Power Co.	Klamath River	(a)	(a)	2,500
North Mountain P. Co.	Trinity River	(a)	(a)	2,680
Great Western P. Co.	Feather River	155	235	54,000
Stanislaus Elec. P. Co.	Stanislaus River	120	145	27,000
American River E. Co.	American River	(a)	(a)	4,000
Truckee River G. E. Co.	Truckee River	(a)	(a)	6,000
Reno P., L. & Water Co.	Truckee River	(a)	(a)	2,000
Big Creek Power Co.	Big Creek	(a)	(a)	1,000
San Joaquin Power Co.	San Joaquin River	(a)	(a)	4,560
Oro W., L. & P. Co.	Feather River	(a)	(a)	4,500
Snow Mtn. W. & P. Co.	Eel River	160	?	5,350
Shasta Power Co.		(a)	(a)	1,600
Tuolumne Water P. Co.	Stanislaus River	(a)	(a)	2,900
Tuolumne E. Co. —	Tuolumne River	(a)	(a)	1,600
La Grange	" "	(a)	(a)	670
Utica Mining Co.—				
Angels	Stanislaus River	(a)	(a)	2,000
	Total Horse-Power			230,450

(a) No connection with Oakland or San Francisco.

On the preceding page will be found a list of all the hydro-electric plants within a radius of approximately 200 miles of San Francisco, together with the length of their transmission lines to Oakland and San Francisco, and the maximum capacity in horse-power of the electrical machinery installed in each plant.

The location of each of these plants is shown on the accompanying map (Plate C).

The horse-power as here given is the maximum capacity of the electric generators, installed in the power houses, when the wheels are supplied with the full amount of water required.

It is well known that very few of these plants have any storage of water, and that a great majority of them are dependent on a variable stream flow, and that in the dry season of even an ordinarily dry year, their output is limited to from one-half to two-thirds of the maximum capacity of their installed machinery.

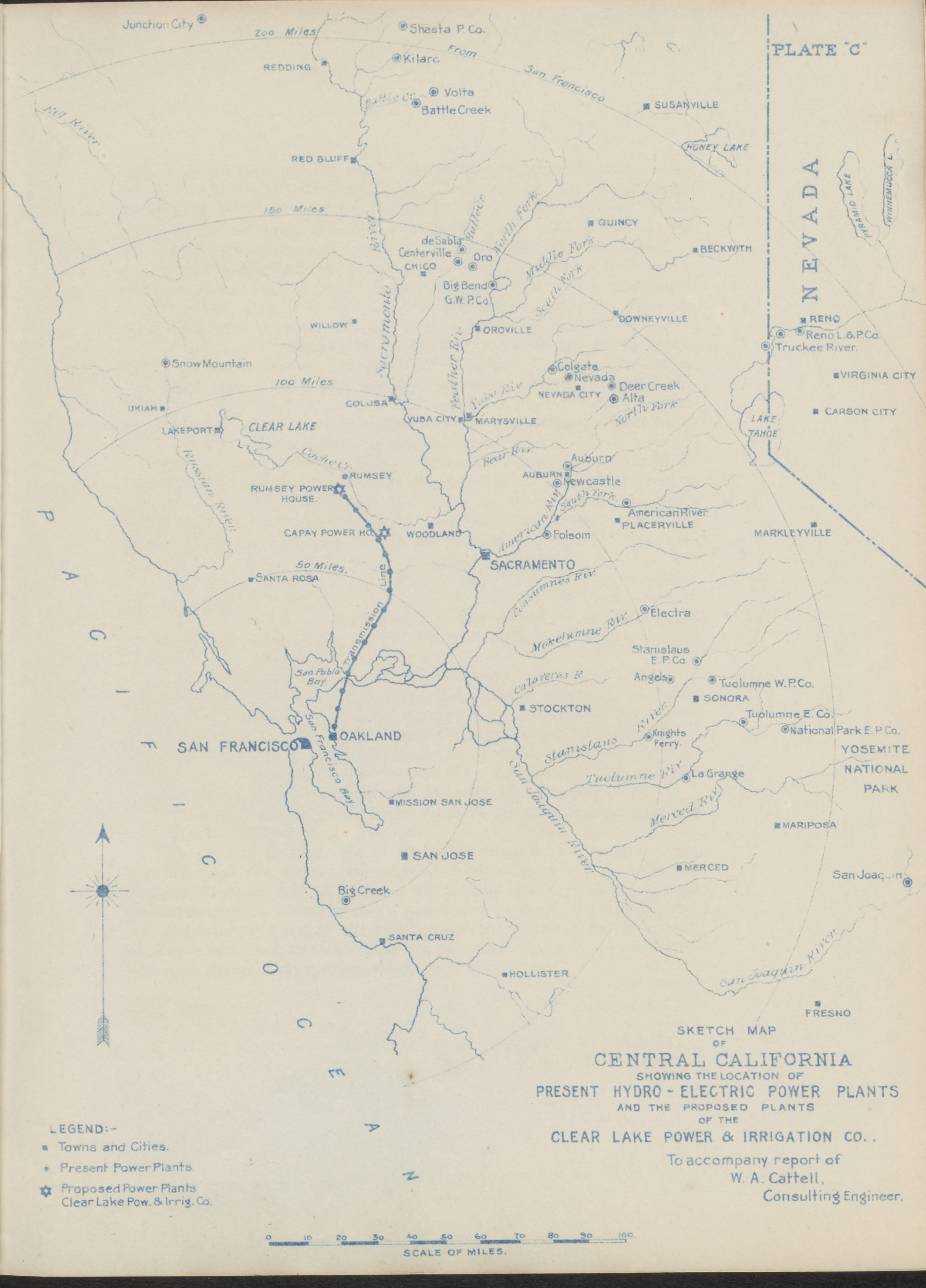
Even assuming that there were sufficient water available to operate all of these plants at their maximum capacity continuously through all seasons, they could not supply the present demand.

The power which is now used in the territory served by these power plants, including San Francisco and the bay district and as far south as San Jose, is conservatively estimated as follows:

San Francisco	100,000	H. P.
Oakland, Berkeley and Alameda	55,000	"
The Bay Counties	15,000	"
San Jose and Peninsula towns	8,000	"
Sacramento, Stockton and the smaller interior towns	32,000	"
Quartz mining	14,500	"
Gold dredgers	12,000	"
Interurban lines	6,000	"
Copper smelters	5,000	"
Pumping for irrigation and reclamation	2,500	"
Total	250,000	H. P.

Of this total of 250,000 H. P. now used, 60 per cent, or 130,000 H. P. is supplied by steam or gas-driven plants, leaving 120,000 H. P. dependent upon the transmission lines of the hydro-electric companies. Taking the total possible output of these plants under the most favorable conditions at 230,450 H. P., as shown on page 39, and assuming an average loss of 15 per cent from the power-house to the consumer, the maximum output which the hydro-electric plants can deliver would be 205,883 H. P., which, under even these favorable conditions would leave approximately 44,000 H. P. to be supplied by steam-driven plants.

In ordinary dry seasons the hydro-electric output would be limited to at most two-thirds of the 205,883 H. P. or 139,255 H. P., and in times of



SKETCH MAP OF

CENTRAL CALIFORNIA

SHOWING THE LOCATION OF PRESENT HYDRO-ELECTRIC POWER PLANTS AND THE PROPOSED PLANTS OF THE CLEAR LAKE POWER & IRRIGATION CO..

To accompany report of W. A. Cattell, Consulting Engineer.

LEGEND:-

- Towns and Cities.
- Present Power Plants.
- Proposed Power Plants Clear Lake Pow. & Irrig. Co.

more than ordinary drought, such as occurred in 1905 and 1908, the total output of all the hydro-electric plants in the territory would not exceed 100,000 H. P. This would be 20,000 H. P. short of supplying the demands of the consumers dependent entirely on transmitted power, and this is a condition which actually obtained in both of the years mentioned.

As the output from the plants of the Clear Lake Power & Irrigation Company would find its logical market in San Francisco on account of its nearness to the city, it is of interest to note the application of the foregoing figures to the power situation in the city of San Francisco.

Of the total of 205,883 H. P. which it is possible for all the hydro-electric plants to deliver, 120,000 H. P. is normally absorbed by the interior and peninsular towns, mining operations, electric railroads, etc., before reaching San Francisco, so that under the most favorable circumstances San Francisco must depend on its steam or gas-driven plants for at least 20 per cent of the power which it consumes.

When the output of the hydro-electric plants drops to 100,000 H. P. San Francisco is not only absolutely dependent on its local plants, but, as has occurred several times in the last three years, power generated by steam plants located within the city limits is actually transmitted back to the mountains for the operation of dredgers and the lighting of towns, situated within a few miles of some of the hydro-electric plants.

At the present time the installation of steam or gas-driven plants in the city of San Francisco exceeds 100,000 H. P. It is therefore correct to state that while at times the city does receive a considerable amount of transmitted power, it was in the dry season of 1908 practically dependent for its supply on its local plants.

These local plants are now operated only because the supply of power reaching the city from the transmission lines is inadequate and cannot be depended upon. At the present prices of coal and fuel oil, power cannot be generated in the San Francisco Bay district even by large installations and under most favorable conditions for less than one cent per kilowatt hour, while the product of the Clear Lake plants could be sold at the rate of eight-tenths cent per K. W. with a handsome profit.

The foregoing statements are based upon the most reliable data and a very careful analysis of the situation.

Taking still another view of the power situation as it exists in San Francisco and the district immediately surrounding the bay, including Oakland, Berkeley and Alameda, it will be seen that the available power from hydro-electric plants is totally inadequate to meet the present demand.

Following is a list of all the hydro-electric plants in the State with possible transmission to Oakland or San Francisco, that is, in any way connected to transmission systems which reach these cities.

HYDRO-ELECTRIC PLANTS WITH POSSIBLE TRANSMISSION TO OAKLAND OR SAN FRANCISCO.

	Length of Transmission in Miles.	Total Generating Machinery Installed, H. P.
de Sabla	179	17,500
Centerville	174	8,600
Colgate	142	19,000
Deer Creek	157	7,400
New Castle	112	1,075
Alta	151	4,000
Auburn	117	670
Folsom	106	5,000
Electra	120	26,800
Kilare	270	4,000
Volta	270	5,700
Battle Creek	270	6,700
Great Western Power	155	54,000
Stanislaus	120	27,000
Snow Mountain	160	5,350
Total		192,795

The above represents the total power it is physically possible to transmit to the two cities, *though a number of the plants here listed as connected with the main transmission lines, are connected only for purposes of local distribution and with no intention of ever sending the power they produce to the bay district.* It is not probable that the total power which could possibly be started for Oakland and San Francisco at any given time, exceeds 175,000 H. P., and this only when all plants connected had a full supply of water and were operating at their maximum capacity. Transmission losses would amount to fully 15 per cent, leaving 148,750 H. P. to be delivered, and in dry seasons this delivery could not exceed 75,000 H. P., while the total consumption of power in San Francisco and the trans-bay cities alone exceeds 155,000 H. P.

The following table was prepared from data contained in the Report of the U. S. Census Bureau for 1906:

POWER IN USE IN CALIFORNIA — ALL INDUSTRIES.

	1900. Horse-Power.	%	1905. Horse-Power.	%	% of Increase, 1905 Over 1900.
Steam engines	105,190	79.0	153,178	69.5	45.6
Gas and gasoline	3,244	2.5	6,292	2.9	94.0
Water wheels	4,680	3.5	7,260	3.3	55.1
Electric motors	6,138	4.6	10,212	4.6	66.2
Other power	1,609	1.2	1,744	0.8	8.4
Rented power—					
Electric	9,624	7.2	39,363	17.8	309.0
Other	2,606	2.0	2,522	1.1	....
Total	133,091	100.0	220,571	100.0	65.7

From the foregoing it will be noted that the total increase of power used in California for all industries, was from 133,091 H. P. in 1900, to 220,571 H. P. in 1905, or 65.7 per cent.

The increase in power from steam engines was 45.6 per cent, while the increase in power developed by gas and gasoline engines was 94 per cent, indicating both the growing efficiency of the latter type of engines and the increasing cost of coal and fuel oil.

The great increase, however, was in the use of electric rented power, which jumped from 9,624 H. P. in 1900 to 39,363 H. P. in 1905, an increase of 309 per cent. This is largely power supplied by the hydro-electric companies, and this increase demonstrates beyond any question of doubt the superior efficiency and economy of this form of power for California, as compared with power developed from any form of fuel.

This report does not give the geographical distribution of the power used in the State, but it states the total number of industries using the 220,570 H. P. in 1905 as 4,206 and that 2,501 of these, or 60 per cent, were located in San Francisco and Oakland. This would indicate the power used in San Francisco and Oakland in 1905 as approximately 132,000 H. P.

The total increase in power used in the State for the four years was, 87,480 H. P., or an average of 17,500 H. P. per annum. This rate of increase has advanced very rapidly in the past four years, and it is now estimated that the annual increase in the use of power in the State is not less than 25,000 H. P., of which 75 per cent, or 18,750, is the present annual increase in the Central and Northern California district. This is conservative, as the consumption of power in this section in 1905 was probably not more than 75 per cent of the total of 220,571 H. P. for the State, or say 165,000 H. P., so that it would require an annual increase of more than 20,000 H. P. to bring the total in four years to the 250,000 H. P. obtained by a careful census of all the existing plants.

This whole territory is growing rapidly in population and wealth, creating each year an additional demand for power for lighting, manufacturing and railways. In the past five years more than 250 miles of electric

interurban and street railway lines have been put in operation in the territory. The writer has personal knowledge of at least 250 miles more of projected electric railways for which surveys have already been made and which will doubtless be built in the near future. The Southern Pacific Co. is already electrifying its suburban lines in Alameda County and is seriously considering the advisability of operating the Mountain Division from Sacramento to Reno by electricity. This operation alone would require about 40,000 H. P.

In the judgment of the writer, it is absolutely safe to estimate that the consumption of power in the section which can be served by the Clear Lake Power & Irrigation Company will increase for the next ten years at an average rate of not less than 18,000 H. P. per annum.

SELLING PRICE OF POWER.

The price which it may be expected to obtain for the product of a hydro-electric plant in California will naturally vary with the conditions under which power is produced and used, and will depend largely on the nature of the load carried and the average load factor on the plant which the connected load produces.

Wholesale prices in the San Francisco Bay district range from 1 to 1½ cents per kilowatt hour, and current to small individual consumers is sold as high as 10 cents per K. W. hour.

The following figures of the San Francisco Gas & Electric Company show the prices at which power is sold in San Francisco:

San Francisco Gas & Electric Company—

	1906.	1907.
Total installed capacity	30,000 H. P.	40,000 H. P.
Gross earnings, sale of electricity	$1,521,033.09	$2,163,307.19
Gross earnings per H.P. per annum	50.70	54.08

In the above the gross earnings are from the official returns of the company to the Board of Supervisors. The total installed horse-power for each year is based upon the full capacity of the transformers and generating machinery in service, but it is exceedingly doubtful if the company could, with the facilities they possess, have carried a continuous load of 30,000 H. P. in 1906 or 40,000 H. P. in 1907.

These figures of $50.70 and $54.08 per H. P. per annum for 1906 and 1907, respectively, represent the gross revenue for power retailed or delivered to small individual consumers involving the construction and maintenance of a distributing system.

The total cost of the distributing system of the San Francisco Gas & Electric Corporation to December 31, 1907, as returned to the Supervisors was $2,566,435.09. Assuming an annual charge of 15 per cent for interest, maintenance and depreciation on this amount and deducting it from the total gross earnings, we would have for 1907 as follows:

Total gross earnings	\$2,163,307.19
15 per cent on \$2,566,435.09	384,965.26
Gross earnings (wholesale)	\$1,778,341.93

$$\frac{\$1{,}778{,}341.93}{40{,}000} = \$44.46 \text{ per H. P. per annum.}$$

This is the equivalent of $1\frac{1}{4}$ cent per K. W. hour on the probable load factor on which these plants operated.

Three interurban railways operating within 50 miles of San Francisco, of which the writer has personal knowledge, purchasing power from the California Gas & Electric Corporation, pay respectively, 1 cent, $1\frac{1}{4}$ cents and $1\frac{1}{2}$ cents per K. W. hour, measured on the high-tension side of the motor-generator sets.

Few contracts are now being made for sale of current, wholesale, at less than 1 cent per K. W. hour, even when the load factor is favorable to the power company. Most of the gold dredgers pay $\frac{8}{10}$ to 1 cent per K. W. hour, though a few have contracts as low as $\frac{65}{100}$ cent, but most of these are located near the power houses, and as they operate from 20 to 22 hours per day, the load factor is very high.

The writer has at hand the exact figures on the selling price of power for a great many California plants, but as these figures have come to him confidentially, in a professional capacity, he is not at liberty to disclose the names of the companies or the exact amounts paid. A very careful study of these contracts, however, shows that at the present time it is safe to estimate \$25 per H. P. per annum on a connected load twice the steady capacity of the plant or for actual energy 8-10 cent per K. W. hour on a 75 per cent load factor, or 1 cent per K. W. hour on a 60 per cent load factor.

The recently constructed California power plants are taking on a connected load from $1\frac{2}{3}$ to $2\frac{1}{2}$ times the continuous load which the power plant can carry, and are contracting to sell power wholesale on the basis of \$25 per connected horse-power per annum.

In the original engineer's prospectus of the Great Western Power Company the minimum flow of the stream was estimated to produce 27,000 H. P. in the Big Bend power house, but this was considered "adequate to the demands of a connected load of 68,000 H. P. at the probable point of consumption, based on the maximum load factor which experience has shown may be realized in such service."—and the gross revenue was estimated at \$25 per H. P. for 68,000 H. P. or \$1,700,000.

It seems to the writer, however, far more rational to estimate the total annual output of a plant on a reasonable and conservative basis, in kilowatt hours and apply to this output the minimum wholesale price for power.

It has already been shown that the output of the Clear Lake plants, estimated on a conservative basis, will be 200,000,000 K. W. hours per

annum. At the minimum rate of $\frac{8}{10}$ of a cent per K. W. hour this would produce a gross revenue of $1,600,000.

MISCELLANEOUS EXPENDITURES AND OBLIGATIONS.

In addition to the above estimates of total cost of each of the three principal divisions of the project, expenditures have been made and obligations created which must be added to obtain the total cost of the completed enterprise, as follows:

Cash Expenditures to Jan. 1, 1909—	
Surveys, administration, etc.	$139,101.30
Interest	27,575.91
Obligations—	
Audited vouchers	50,000.00
Bonds—Central California Power Co.	60,000.00
Discount on debentures	9,300.00
Total of miscellaneous expenditures and obligations to Jan. 1, 1909	$285,977.21

INTEREST DURING CONSTRUCTION.

The interest charges, during the construction of the works involved in this project will be, comparatively, a small amount, as the earnings from irrigation will begin as soon as the dam at the outlet of the Lake is constructed. This dam can be built quickly and at small cost.

Further: The earnings from sale of power will also begin as soon as the Capay Power House is put in service, and this can be done within one year after active work is commenced. The earnings from these sources will probably more than meet all interest charges during construction, but to allow for contingencies it might be well to add one year's interest, on an average of $5,000,000, at 5 per cent, or $250,000.

ADMINISTRATION AND LEGAL EXPENSES.

A liberal allowance for administration, legal and miscellaneous expenses not already included, would be $250,000 for the entire construction period.

TOTAL COST OF PROJECT.

Summing up the foregoing, we would have as the total cost of the completed project, including lands, water rights, construction, interest and administration expenses:

(1) Total cost of acquiring lands and water rights	$2,158,240.82
(2) Total cost of power development and transmission	4,085,000.00
(3) Total cost of Yolo County Water Company, purchase and extensions	928,914.87
Miscellaneous expenditures and obligations	285,977.21
Interest during construction	250,000.00
Administration and legal	250,000.00
Total cost of project	$7,958,132.90
Of this total amount there has been paid	658,665.00
Leaving balance to complete	$7,299,467.90
OR SAY IN ROUND NUMBERS	$7,500,000.00

This amount will complete the purchase of all properties merged into the Clear Lake Power & Irrigation Company, retire absolutely all outstanding obligations of the various companies merged, including debentures, bonds and notes payable and provide all funds necessary for the construction of power plants and transmission lines and the initial extension of the irrigation system.

BOND ISSUE.

To provide the required $7,500,000 it will be necessary to issue $9,000,000, 5 per cent bonds, which at 85 will net $7,500,000. The interest on this issue would be $450,000 per annum.

OPERATING EXPENSES.

The project as herein outlined contemplates the delivery of power wholesale or in large blocks. This together with the short transmission line with durable steel towers and the substantial character of the power houses and conduits, will reduce operating and maintenance expenses to a minimum. The writer estimates that the operation of the power and irrigation features, including maintenance, insurance and taxes, will not exceed $250,000 per annum.

NET EARNINGS.

The net earnings of the entire project would be, therefore, after payment of bond interest and operating expenses:

Gross Earnings from Power	$1,600,000.00	
Gross Earnings from Irrigation	400,000.00	
Total		$2,000,000.00
Expenses—		
Bond Interest	$ 450,000.00	
Operating Expenses	250,000.00	
Total		700,000.00
NET EARNINGS		$1,300,000.00

PROFITS FROM SALE OF LANDS AND WATER RIGHTS.

It will be noted in the foregoing statements, that the cost of acquiring lands is $2,158,240.82. Assuming the entire cost of these lands as charged against the expense of creating a storage reservoir for power and irrigation purposes, the project works out to be a most profitable investment. But these lands will ultimately acquire a greatly enhanced value for other purposes.

Those who have not visited Clear Lake will find difficulty in understanding any description of its attractions and possibilities as a health and pleasure resort, the writer therefore will not attempt any special description of these features other than the mere statement which will be confirmed by a visit to the Lake and its surrounding territory, that around the shores of the Lake are hundreds of the most beautiful villa sites to be found in California. The valleys opening out from the Lake are rich and fertile and produce abundant crops of fruits, vegetables and nuts. Here the English walnut grows to perfection. Every variety of scenery is represented from rugged hills to pictureesque oak-studded meadows. The climate, both summer and winter, is ideal. But for its inaccessibility, the shores of Clear Lake would have been long ago crowded with seekers for health and pleasure. Even as it is, it is estimated that from 40,000 to 50,000 people visit the Lake every year.

There is already a demand for villa sites around the Lake, and with the advent of railroad trnasportation this demand will increase very rapidly.

Of the total of 50,281.8 acres of land which have been acquired in connection with this project, the writer estimates that after reserving all lands and rights along the Lake Shore needed for the use of the Lake as a storage reservoir, at least 25,000 acres can be sold for villa sites, residences and agricultural purposes at an average of not less than $200 per acre, which would net a profit from these lands of $5,000,000.

It will probably require from 6 to 10 years to dispose of this land and the full value can not be developed until direct railroad comunication with the Lake is established. But these lands will be a most valuable asset of the Company, in addition to the high earning capacity of the plant.

It is further estimated that the water rights on the 200,000 acres of land which will be irrigated can be sold for at least $15 per acre, of which $5 will be applied to extending the irrigation system, leaving a net profit on the 200,000 acres, of $2,000,000. These profits may be used for retiring bonds or distributed as extra dividends to the stockholders.

AUXILIARY STEAM PLANT.

A number of Long Distance Transmission Companies now operating in California have installed auxiliary steam plants in connection with their Hydro-electric developments.

Most of these steam plants are maintained because the companies suffer severely from lack of water in dry seasons and are unable to carry

their loads with the Hydraulic plants, and further because the long transmission lines, many miles of which are in heavily timbered country, are subject to destruction by forest fires, and the character of the ditches and timber flumes supplying the plants with water is such that they are all too frequently put out of commission by flood or fire, with a consequent interruption of service which must be then supplied by the Steam Plants.

The transmission line of the Clear Lake Power & Irrigation Company will be but 80 miles in length, through an open country, and so constructed that the chances of destruction by fire or flood will be reduced to a minimum.

There will be no timber flume to burn and the ditches and tunnels will be of the most substantial character.

The amount of power which has been stated as the power which these plants will produce, is the *minimum* which can be developed continuously in the dryest seasons on record and no steam plant will be needed on account of shortage of water.

It is the best judgment of the writer, therefore, that it will not be necessary to install an auxiliary steam plant in connection with the Clear Lake Power & Irrigation project. If, however, it is found advisable at any time to do this, the cost of such a plant could be easily met, as the additional revenue it would produce would more than pay the interest on the cost of its construction.

Assuming the installation of an auxiliary steam plant of 15,000 Kilowatt capacity at the extreme cost of $150 per K. W. for land, building and machinery the total cost would be $2,250,000.

By referring again to the discussion of the amount of water available, it will be noted that the average flow from the Lake is more than 50 per cent greater that the minimum flow on which the present estimate of power to be generated is based. This surplus water, used in connection with a steam plant, can be counted on to deliver 100,000,000 K. W. hours per annum in addition to the 200,000,000 K. W. hours which the Hydro-electric plants alone will produce. But assuming that the surplus power developed would be only one-half of this, or 50,000,000 K. W. hours, the additional revenue at $\frac{8}{10}$ of a cent per K. W. hour would be $400,000 per annum, while the interest on $3,000,000 of bonds at 5 per cent would be but $150,000.

A careful marketing of the output of the Clear Lake Power & Irrigation Company's plants to the consumers now operating steam plants in San Francisco and the Bay District will probably enable the Company to secure a large part of this additional revenue without the necessity of constructing an auxiliary steam plant of its own, as such consumers, now dependent on an irregular and inadequate supply of transmitted power, and forced to operate their steam plants for a considerable period each year, will be plad to contract for a supply of steady and reliable electric power which would reduce the operation of their steam plants to a minimum.

In view of these facts, the writer does not recommend the installation of an auxiliary steam plant at the present time.

CONCLUDING REMARKS.

It is a difficult matter to discuss so large and varied a project, as that of the Clear Lake Power & Irrigation Company, within the limits of a report which would not be wearisome to read. The writer has, therefore, omitted many interesting features and details and has endeavored to set forth only the more important features, such as the supply of water, the power it will generate, the lands that may be irrigated, the total cost of the project, and earnings which may be depended on.

Of the features which have been treated in some detail, the writer wishes to emphasize certain points, among these are:

That there is no other source of Hydro-electric power, of any magnitude, within the same distance from San Francisco.

That the control of the shores of Clear Lake which this Company has obtained, will permit the creation of a storage reservoir, which for size and reliability cannot be duplicated within 200 miles of San Francisco, for several times the cost of the lands which have been acquired.

That the transmission line of the Clear Lake Power & Irrigation Company will be not only the shortest, but also the best protected, of any of the transmission systems, and that this, together with the substantial and permanent conduit line, which is easily attainable in this case, will make the whole system, in a marked degree, less liable to interruption of service, than any other system in the State.

That the harmony of interest which exists in this project between the power and irrigation features is one which seldom occurs, the development of power takes nothing from irrigation, and the irrigation of large areas of land exacts no sacrifice of power. The water which other power companies must waste after they have developed their power, is here made to produce an additional and substantial revenue.

The lands, too, which have been acquired primarily for the purpose of creating a storage reservoir, will in time be made to yield a handsome profit, while in other projects of a similar nature, the lands acquired for such purpose must be submerged and their value for other uses destroyed forever.

Volumes have been written on the beauties and possibilities of Clear Lake as a health and pleasure resort, but no description can give an adequate idea of these possibilities. They must be seen and studied to be appreciated.

It has already been stated that the full value of the lands around the Lake will be developed only when railroad transportation to the Lake is provided. The project of building a railroad into Lake County has been under consideration for some years, and while the building of such a railroad must remain more or less problematical until it is actually constructed, it is much nearer realization than is generally supposed. Two very strong companies are now in the field for this purpose. One has already expended more than $300,000 for surveys, terminals and rights of way, and the other, which would connect with the Northwestern Pacific Railway

at Pieta, is strongly supported by local interests and has the backing of the Northwestern Pacific Company. The development of Lake County has been so long retarded by the lack of this railroad, it does not seem reasonable to suppose that its construction can be much longer delayed. On the contrary, it seems to the writer reasonably certain that direct railroad communication to the Lake will be established within the next two or three years. Should the present railroad projects be delayed in their accomplishment, the Company could itself build a line at small cost, to be operated with gasoline motors, and which would answer all practical purposes. With the advent of such a railroad, the prosperity of Lake County and the greatly enhanced value of the Company's holdings around the Lake is assured.

The irrigation features, too, are unique as compared with irrigation projects, as generally understood. It is not a colonization scheme, it is not putting water on arid and worthless land in order to create a value and make its cultivation possible. The lands to be irrigated are all occupied and cultivated, are now producing good crops and held at high prices, but the average rainfall in the Sacramento Valley is not sufficient to secure the best results, and needs to be supplemented by irrigation.

Under the conditions which exist in Yolo and Solano Counties, the supply of a very limited amount of water by irrigation will double and in many cases triple the value of lands, now held at from $60 to $100 per acre. The farmers and fruit growers are already there, they are prosperous and fully alive to the situation and will be glad to pay $15 to $20 per acre for water rights which will add four or five times this amount to the value of their land.

It has already been pointed out that both of the proposed Power Houses are located close to a railroad, and there will be no costly mountain roads to build, and no hauling of machinery and construction materials. The only haul of any consequence will be for the cement required to build the dams and for the concrete tunnel linings.

The total tonnage of cement required for dams and tunnels is insignificant as compared with the magnitude of the work. Timber and rock for construction purposes can be found within a few miles of the line of the conduit.

The Capay Power House can easily be put in operation within a year after active work is commenced, and the power from this plant used to drive the compressors on the longer tunnels, thus decreasing the cost of the work and expediting its progress.

The estimates which have been presented are liberal, and contain ample allowance for all possible contingencies.

The estimate of earnings is conservative and there is not the slightest doubt in the mind of the writer that, if properly handled, the project will work out in every detail to give even greater returns than have been stated.

Respectfully submitted,

W. A. Cattell.

APPENDIX "A" :: COPY OF LETTER *from* A. M. HUNT, CONSULTING ENGINEER.

[COPY.]

A. M. Hunt,
Mem. Am. Soc. C.E.
Mem. Am. Soc. M. E.
Mem. Am. I. E. E.

Union Trust Building.
Tel. Kearny 4470

San Francisco, Apr. 20th, 1909.

Mr. W. A. Cattell,

Dear Sir:

At your request I have carefully studied your report on the proposed development of power from the waters of Clear Lake, and the data on which it is based.

I am familiar with the various plans which have been proposed in the last twelve years for developing this source of power, and have always expressed the opinion that no development of the full power could be made without control of all properties abutting on the Lake, in order that its full storage capacity as a reservoir could be utilized. With such marginal control as is shown by your report, the project becomes an entirely feasible one.

As to quantity of water available, your conclusions seem to me justifiable, and from my own experience and study of the problem, I feel satisfied that an average flow of 500 cubic feet per second can be maintained.

I am personally familiar with the outlet of Clear Lake, and the problem of conserving the water and controlling the flow is a simple one, involving no serious engineering problems.

I am not familiar with the route to be traversed by the water conduit, except for a few miles of its upper portion. However, I am generally acquainted with the country traversed, and after a careful scrutiny of the details of the cost as estimated by you, I am of the opinion that your estimate of $4,085,000 for a plant having a capacity of 40,000 continuous horse power is a safe one. This amount covers all physical structures, including transmission to San Francisco, but does not include lands acquired and to be acquired in connection with the Lake control.

I have recently made a careful analysis of the market conditions for power in the central section of the State, with especial reference to the San Francisco Bay District, reaching the following conclusions:

(1) The amount of plant capacity absorbed in the central section of the State is approximately 246,000 horse power, about 177,000 of which is used in the Bay District.

(2) The market is more than sufficient to absorb the capacity of the various Hydro-electric plants now operating and building, with such increases as they contemplate.

(3) The normal annual increase in power demand in the central section of the State has for several years past been not less than 17,500 horse power, and may be expected to continue at not less than this rate during the next few years.

(4) A ready market should be found for such an amount of power as you propose by the time the plant would be ready to operate.

(5) Based on past and present conditions, and with full consideration given to the probabilities of the future, such power should find a wholesale market at a rate of not less than eight-tenths of a cent per Kilowatt hour.

If penstock reservoirs are provided to enable the daily demand for water to be averaged, it should be possible to deliver from the plants at the market points approximately 200,000,000 Kilowatt hours per year, or the possible gross income from sale of power would be $1,600,000. I am,

Yours very truly,

(*Signed*) A. M. HUNT.

APPENDIX "B" :: COPY *of* LETTER *from* RUDOLPH W. VAN NORDEN, CONSULTING ENGINEER.

R. W. VAN NORDEN,
Consulting Engineer,
912-914 Mutual Bank Bldg.

San Francisco, Cal., April 26, 1909.

Mr. W. A. CATTELL,
Lick Building,
San Francisco, Cal.

Dear Sir:

The report which you have completed, concerning the proposed power development and the subsequent use of the water from Clear Lake, for irrigation, I have read over carefully, at your request.

I am thoroughly familiar with all phases of this proposed power development, having spent over two years in the study of the features entering into the problem.

Your conclusions are correct, both as to the amount of water available and the cost of development, and bear out my own statements made in my report on the project, dated April 16th, 1907.

I am fully convinced that the series of tunnels for the canal system is the most practical and at the same time the cheapest method of construction, especially in view of the fact that there are no long hauls from railroad transportation.

With a thorough knowledge of all of the important power plants on the Pacific Coast, I would say that this system will be, not only a very simple one to operate, but more free from the possibility of interruption than any other existing plant.

The transmission line to Oakland or San Francisco is much shorter than any existing or proposed system delivering power to these plants, thus greatly cutting down the probability of interruption from line troubles and also the cost of operation. It will have the further advantage of being protected from the prevailing winds and at all times within sight of a railroad.

There is no doubt in my mind, after the most thorough consideration that your estimate of $4,085,000 is very ample to construct the entire power system, exclusive of the cost of water rights and lands around Clear Lake.

The question of the future demand for power, I have studied with great care and made a series of reports on the subject in November, 1907. There is a very distinctly increasing ratio in the growing demand for power to the increase of population in the San Francisco Bay District and the conclusions which you have arrived at are undoubtedly correct.

This system will deliver 200,000,000 Kilowatt hours per year.

Yours respectfully,

(*Signed*) RUDOLPH W. VAN NORDEN.

APPENDIX "C" :: COPY *of* LETTER *from* ATTORNEY CHARLES S. WHEELER.

Charles S. Wheeler,
Law Offices.
Union Trust Building.
Cable Address "*Advocate*"
Western Union Code.

San Francisco, Cal., May 3rd, 1909.

W. A. Cattell, Esq.,
Consulting Engineer, Clear Lake Power & Irrigation Co.,
San Francisco, California.

Dear Sir:

Replying to your inquiries concerning the legal status of the Clear Lake proposition, I beg to say, that the Company holds, either in fee simple or under contract, substantially all of the lands fronting on the Lake. I believe that it will be able to secure by purchase all of the frontage not now held, without delay, as soon as it is in a position to commence active work. If, however, there should be any disappointment in this regard, the company has the right to acquire all of the necessary lands by condemnation. This process under our statutes is a speedy one, and the desired result can be accomplished without great expense and the title can be secured, by the time our dam is completed. As I have said, I anticipate not the slightest trouble in this regard. The public sentiment of the county is strongly in our favor, and any person who seeks to block the enterprise or to hold the company up for an exorbitant figure would meet with little favor with a Lake County jury.

There are no extraordinary or unusual difficulties confronting the rest of the enterprise so far as the legal end is concerned.

Yours truly,
(*Signed*) Charles S. Wheeler.

20